Appendix D
New Mexico Greenhouse Gas Inventory and Reference Case Projections, 1990-2020

Prepared for the:
New Mexico Environment Department

By the:
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November 2006[1]

[1] Original draft completed July 2005. Second draft completed February 2006. Final technical changes completed November 2006.

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Acronyms and Key Terms

AEO2005 – US DOE Energy Information Administration's Annual Energy Outlook 2005
BCF – Billion cubic feet
BLM – Bureau of Land Management
CBM – Coal-bed Methane
CH4 – Methane*
CO2 – Carbon Dioxide*
CO2e – Carbon Dioxide equivalent*
EIA – US DOE Energy Information Administration
EMNRD - Energy, Minerals and Natural Resources Department
FIA – Forest Inventory Analysis (US Forest Service)
FHWA – Federal Highway Administration
GHG – Greenhouse Gases*
GNP – Gross National Product
GSP – Gross State Product
GWP - Global Warming Potential*
GWh – Gigawatt-hours (1 million kilowatt-hours)
HFCs – Hydrofluorocarbons*
IPCC – Intergovernmental Panel on Climate Change*
KWh – Kilowatt-hour
Mt - Metric ton (equivalent to 1.102 short tons)
MMt – Million Metric tons
MTBE – Methyl Tertiary Butyl Ether
MWh – Megawatt-hours (1 thousand kilowatt-hours)
NMED – New Mexico Environment Department
NMDOT – New Mexico Department of Transportation
NMOGA – New Mexico Oil and Gas Association
N2O – Nitrous Oxide*
ODS – Ozone-Depleting Substances
PFCs – Perfluorocarbons*
PNM – Public Service of New Mexico
RCI – Residential, Commercial, and Industrial
RPS – Renewable Portfolio Standard
SEDS – US DOE Energy Information Administration's State Energy Data System
SGIT – US EPA State Greenhouse gas Inventory Tool
SF6 – Sulfur Hexafluoride*
Sinks – Removals of carbon from the atmosphere, with the carbon stored in forests, soils, landfills, wood structures, or other biomass-related products.
US EPA – US Environmental Protection Agency
US DOE – US Department of Energy
TWh – Terawatt-hours (1 billion kilowatt-hours)
VMT – Vehicle-miles Traveled
WRAP – Western Regional Air Partnership

* - See Attachment D-9 for more information.

Acknowledgements

We appreciate all of the time and assistance provided by numerous contacts throughout New Mexico, as well as in neighboring states, and at federal agencies. Most of these contacts are listed in Attachment D-8 – our apologies to those not listed, as we recognize this list is far from complete. Thanks go to in particular the many staff at several New Mexico state agencies for their inputs, and in particular to Lany Weaver and Brad Musick of the New Mexico Environment Department who provided key guidance for this analytical effort.

1. Summary of Findings

Introduction

This report presents estimates of historical and projected New Mexico anthropogenic greenhouse gas (GHG) emissions and sinks for the period from 1990 to 2020. These estimates are intended to assist the State, stakeholders and technical work groups with as comprehensive as practicable an understanding of current and possible future New Mexico greenhouse gas (GHG) emissions, and thereby inform the analysis and design of GHG mitigation strategies.

Historical GHG emissions estimates (1990 through 2003)[2] were developed using a set of generally-accepted principles and guidelines for State greenhouse gas emissions, as described in Section 2, relying to the extent possible on New Mexico-specific data and inputs.[3] The reference case projections out to 2020 are based on a compilation of various existing New Mexico and regional projections of electricity generation, fuel use, and other GHG emitting activities, along with a set of simple, transparent assumptions described later in this report. These estimates should be viewed as input to the New Mexico Climate Change Advisory Group (NMCCAG) process.

This report covers the six types of gases included in the US Greenhouse Gas Inventory: carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6). Emissions of these greenhouse gases are presented using a common metric, CO2 equivalence (CO2e), which indicates the relative contribution of each gas to global average radiative forcing on a Global Warming Potential (GWP) weighted basis. Attachment D-9 provides a more full discussion of greenhouse gases and GWPs.

New Mexico Greenhouse Gas Emissions: Sources and Trends

The analysis suggests that in 2000, New Mexico produced about 83 million metric tons[4] (MMt) of *gross* carbon dioxide equivalent (CO2e) emissions, an amount equal to 1.2% of total *gross* US GHG emissions.[5] Gross emissions include all major sources and gases, most notably the combustion of fossil fuels in power plants, vehicles, buildings, and industries (82% of total State

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[2] For some sectors and sources, historical data are only available through 2000, 2001 or 2002.

[3] A starting point for this analysis was the 1996 New Mexico GHG emissions inventory prepared by the Waste Management Education and Research Consortium (WERC) as part of *New Mexico Greenhouse Gas Action Plan: Enhancing our Future through Mitigation* (WERC 2002). This report included a single historical year (1996) and a more limited set of emissions sources and gases than included here. WERC is a consortium of the New Mexico State University, the University of New Mexico, the New Mexico Institute of Mining and Technology, and Diné College in collaboration with Sandia National Laboratories and Los Alamos National Laboratory.

[4] All GHG emissions are reported here in metric tons.

[5] United States emissions estimates are drawn from Climate Analysis Indicators Tool (CAIT) version 1.5. (Washington, DC: World Resources Institute, 2003), which is based on official USEPA reports. Available at: http://cait.wri.org.

emissions), the release of methane from oil and gas production, coal mines, agriculture, and waste management (13%), and other sources such industrial processes and nitrous oxide from agricultural soils (5%).

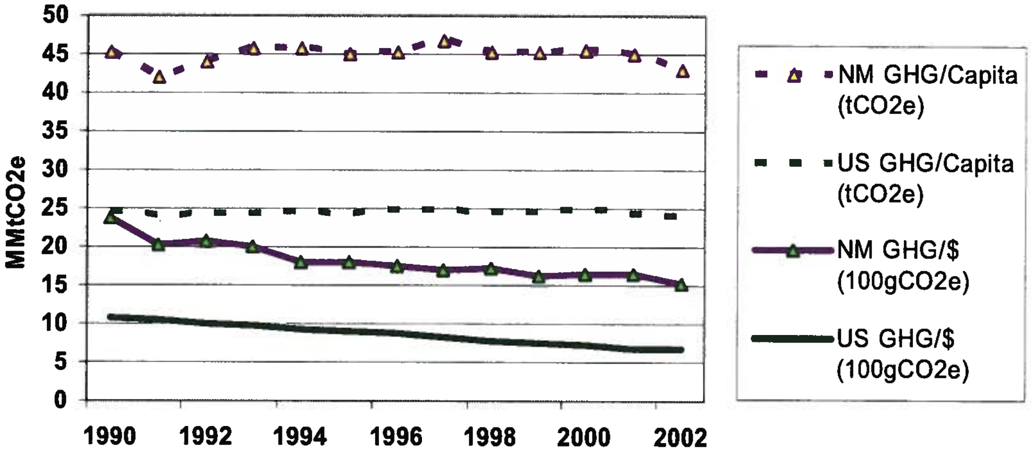
Net emissions combine gross emissions sources with carbon sequestered and released from biomass throughout the State. Very preliminary estimates suggest that from the late 1980s through the late 1990s, New Mexico's forest areas sequestered about 21 MMtCO2e per year. If these estimates are applied to 2000, the State's *net* GHG emissions would be 62 MMtCO2e, about 25% lower than the gross emissions estimate. However, there are rather large uncertainties regarding changes in carbon stocks in New Mexico forestlands since 1997, the year that the US Forest Service conducted its most recent forest inventory in the State, especially given drought and disease conditions since that time. Therefore, we focus most of this section on gross emissions sources, for which there is greater certainty. Net emissions are also shown below, using the only historical estimates available as a placeholder until better estimates are available.

The State's gross GHG emissions increased by about 21% during the 1990s, somewhat slower than the US as a whole, where emissions rose by 23%. This slower increase appears largely attributable to a few key factors, in particular limited growth in new power generation facilities and the decline of the mining industry and its fuel and electricity requirements. Were it not for these factors, New Mexico's emissions could well have increased as fast as, or faster than, the national average, given the State's more rapid population and economic growth.[6] Transportation-related GHG emissions, which are driven directly by fuel use and in turn by population, rose by 29% in the 1990s, and represent one of the State's fastest growing GHG emissions sources.

On a per capita basis, New Mexico produces near twice the GHG emissions as the national average (45 vs. 25 tCO2e per person). New Mexico's high per capita emissions are largely the result of its GHG-intensive gas, oil, and electricity production industries. Figure D-1 shows that, like the nation as a whole, per capita emissions have remained fairly flat, while economic growth outpaced emissions growth throughout the 1990-2002 period. During the 1990s, gross GHG emissions per unit of gross product dropped by 33% nationally, and by 31% in New Mexico.

[6] During the 1990s, population grew by 20% in New Mexico compared with 13% nationally, and state GSP grew by 76% compared with national GDP growth of 72%.

Figure D-1. New Mexico and US GHG Emissions, Per Capita and Per Unit Gross Product (2000$)



In addition to being a key facet of the State's economy, as noted, energy producing industries are the dominant feature of New Mexico's GHG emissions profile. Together, the production of electricity and fossil fuels accounted for two-thirds of New Mexico's gross GHG emissions in the year 2000, as shown in Figure D-2. In comparison, these activities accounted for only 35 to 40% of national gross GHG emissions.[7]

Emissions of greenhouse gases by electric power plants, the State's leading emission source, are relatively well understood, and are for the most part (carbon dioxide at facilities over 25 MW) continuously monitored. Over 90% of these emissions occur at the State's coal-fired facilities, and two plants, San Juan and Four Corners, account for about three-quarters. Natural gas-fired power plants produce the remaining emissions from this sector.

Emissions of carbon dioxide and methane occur at many stages of the fossil fuel production and delivery process (drilling, production, processing/refining, and pipeline transport), and can be highly dependent upon local resource characteristics (e.g., pressure, depth, water content, gas concentrations), technologies applied, and practices employed at individual wells sites and compressor stations. With over 40,000 oil and gas wells, three oil refineries, several gas processing plants, and tens of thousands of miles of gas pipelines in the State – and no regulatory requirements to track CO_2 or CH_4 emissions – there are significant uncertainties with respect to the State's GHG emissions from this sector.

Preliminary estimates however, suggest that fossil fuel industry emissions are quite high. The majority of emissions come from natural gas production, with significant emissions resulting from fuel use at field sites, processing plants, and pipelines (6 MMtCO2), the release of associated CO2 found in the coalbed methane from the Fruitland field in the San Juan Basin (5

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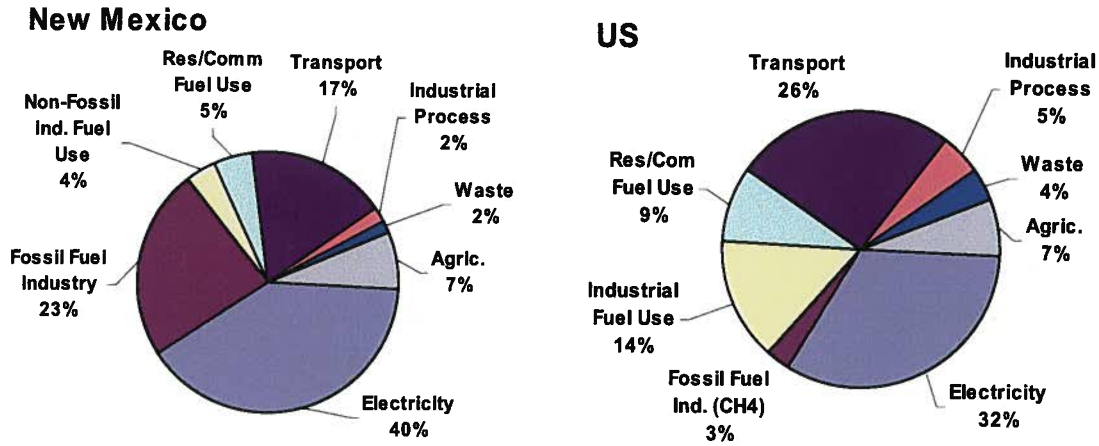
[7] Fuel use for field, processing, and pipeline operations are included in the fossil fuel industry for New Mexico; however, such fuel use is not disaggregated in the national inventory, and thus constitutes a fraction of the slice shown for US industrial fuel use.

MMtCO2), and methane vented and flashed at well sites, processing plants, and pipelines (5 MMtCO2e). Further analysis is needed to resolve some of the large unknowns regarding these and other oil and gas sector emissions.

Figure D-2. Gross GHG Emissions by Sector and Gas, 2000, New Mexico and US



As a fraction of total GHG emissions, transportation accounted for 17% of New Mexico emissions, compared with 26% of national emissions. However, on a per capita basis, New Mexicans actually consume more gasoline and diesel fuel, and produce more transportation-related GHG emissions, than the average American.

The remaining use of fossil fuels – natural gas, oil products, and coal -- constitutes another 9% of State emissions, about half in residential and commercial buildings and the other half among non-fossil-fuel industrial (RCI) sectors. While GHG emissions from residential and commercial fuel use grew about 10% from 1990 to 2000, industrial fuel use grew in the early 1990s, but has since declined, most likely a reflection of reducing mining and smelting activity in the State.

Agricultural activities such as manure management, fertilizer use, and livestock (enteric fermentation) result in methane and nitrous oxide emissions that account for 7% of State GHG emissions. These emissions grew by over 30% from 1990 to 2000, the result of rapidly expanding dairy operations in the State.

Industrial process emissions comprise about 2% of State GHG emissions today. Three sources each account for about one-third of these emissions in the year 2000: the use of hydrofluorocarbons (HFCs) as substitutes for ozone-depleting substances (ODS) such as chlorofluorocarbons and hydrochlorofluorocarbons[8], the use of perfluorocarbons (PFC) in semiconductor manufacture, and carbon dioxide released during the calcination process in cement production. Since the year 2000, efforts by semiconductor industries, Intel, in particular,

[8] Chlorofluorocarbons and hydrochlorofluorocarbons are also potent greenhouse gases; however they are not included in GHG estimates because of concerns related to implementation of the Montreal Protocol. See Attachment D-9.

have led to substantial reductions in PFC emissions. However, the increasing use of HFCs is leading to rapid growth in this emissions category.

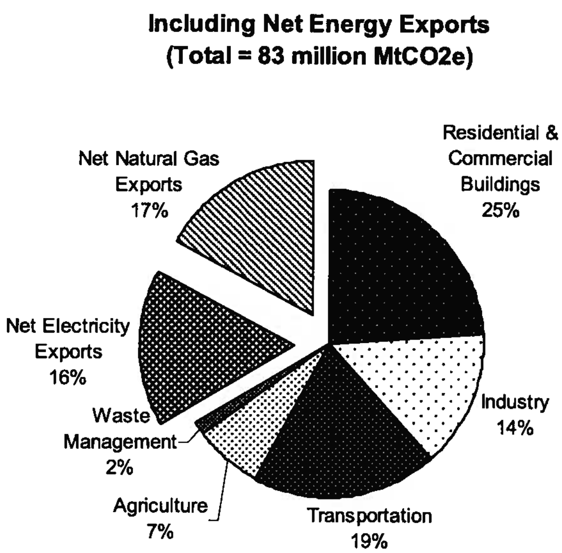
Landfills and wastewater management facilities produce methane and nitrous oxide emissions accounting for the remaining 2% of current State emissions in 2000. These emissions have increased slightly in recent years with increased landfilled waste; however, they have begun to stabilize and decline as landfill gas is increasingly captured and flared or used for energy purposes.

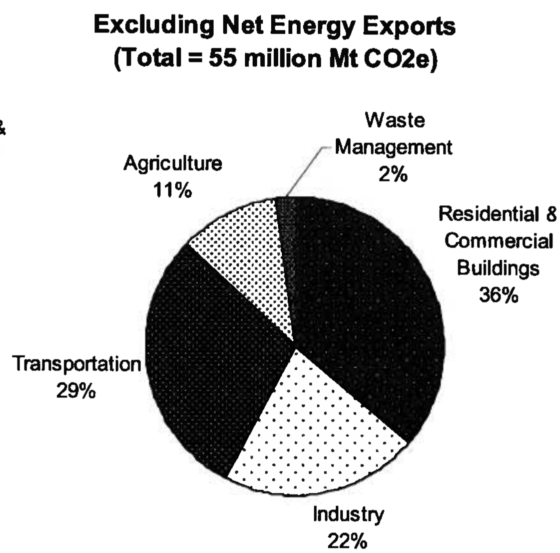
Box 1: Another Way to Look at New Mexico Greenhouse Gas Emissions

During the review of the draft inventory, members of the Residential, Commercial, and Industrial Technical Working Group suggested another, useful representation of the state's GHG emissions. The figures below illustrate the state's emissions by economic sector, incorporating the emissions associated with delivering electricity and fossil fuels used by these sectors. This gives a sense of the contributions of activity in each sector to overall emissions, as well as the level of effort that might be needed to achieve overall emissions reductions in line with state goals.

The left hand pie chart shows that, of the state's estimated 83 million MtCO2e of GHG emissions in 2000, about one-third was associated with electricity and natural production in excess of state consumption levels ("net exports"). Excluding these slices, and looking only at the in-state sectors, the right hand pie chart shows that of the remaining 55 million MtCO2e in GHG emissions, about 36% are associated with residential and commercial building energy consumption, 22% with industrial energy consumption and process GHG emissions, 29% with transportation fuel use, 11% with agricultural activities, and 2% with waste management emissions. (It was further noted by the RCI Technical Working Group that some industrial GHG emissions, e.g. from steel or cement production, are influenced by the design of, and materials used in, residential and commercial buildings.)

Representation of NM GHG Emissions by Consuming Sector



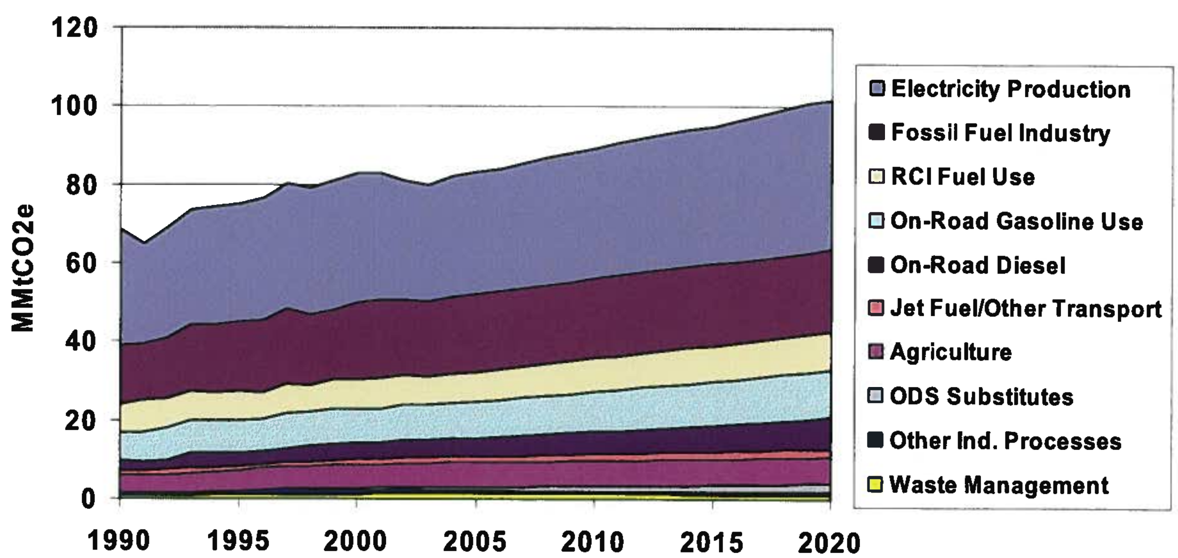


Reference Case Projections

Relying on US DOE and New Mexico agency projections of population, employment, and electricity use, input from NMED staff and industry experts, we developed a simple reference case projection of GHG emissions through 2020.[9] The reference case assumes a continuation of current trends and reflects, to the extent possible, power plants under construction and the implementation of recently enacted policies, such as the State's Renewable Portfolio Standard, which currently requires investor-owned utilities to provide 10% of the electricity sales from renewable sources by 2011.[10] As reference case projections were finalized through collaboration with stakeholders and technical work groups, it was important to consider other existing and planned actions, as well as the basic assumption underlying these projections (See Table D-3 below and further information in the Attachments).

As illustrated in Figure D-3 and shown numerically in Table D-1, under the reference case projection, New Mexico's gross GHG emissions are projected to grow steadily from recent levels. (For more details on emissions by source, see Table D-5 at the end of this section.) By 2010 they would reach 89 MMtCO2e, 8% above year 2000 levels. By 2020, they would climb another 14% to 102 $MMtCO_2e$, which corresponds to a total increase of 23% above year 2000 levels. These decadal increases would be slower than New Mexico's 21% increase in GHG emissions from 1990 to 2000.

Figure D-3. Gross GHG Emissions by Sector, 1990-2020: Historical and Projected



[9] Historical data runs through 2001 to 2003 depending on the emissions source.

[10] http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=NM05R&state=NM&CurrentPageID=1

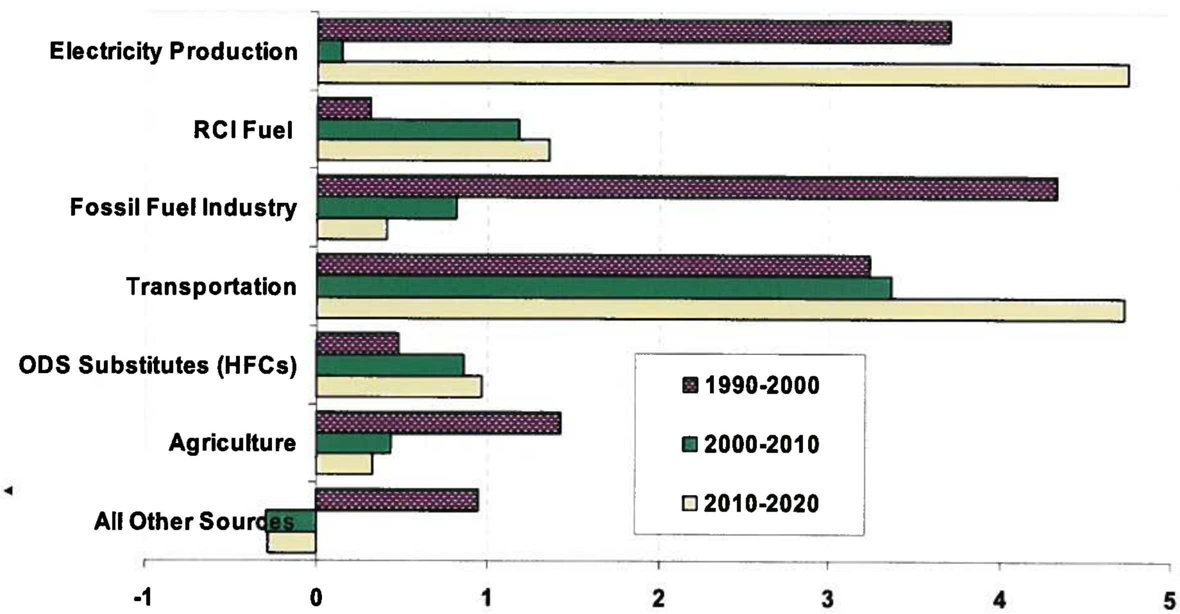
Table D-1. New Mexico GHG Emissions, Reference Case – Production Based[11]

(Million Metric Tons CO2e)	1990	2000	2010	2020
Energy	**62.6**	**74.2**	**79.7**	**91.7**
Electricity Production	29.5	33.2	33.3	38.8
Transportation Fuel Use	11.0	14.2	17.6	22.3
Fossil Fuel Industry	15.2	19.5	20.3	20.7
Res/Comm/Other Ind. Fuel Use	7.0	7.3	8.5	9.9
Other	**5.9**	**8.7**	**9.7**	**10.8**
Industrial Processes	0.5	1.5	2.0	2.8
Agriculture	4.5	6.0	6.4	6.7
Waste Management	0.8	1.2	1.4	1.2
Gross Emissions	**68.5**	**82.9**	**89.4**	**102.4**
change relative to 1990		*+21%*	*+31%*	*+48%*
change relative to 2000			*+8%*	*+23%*
Forestry and Land Use	***-20.9***	***-20.9***	***-20.9***	***-20.9***
Net Emissions (includes Forestry and Land Use)	**47.6**	**62.0**	**68.5**	**81.5**
change relative to 1990		*+30%*	*+44%*	*+71%*
change relative to 2000			*+11%*	*+31%*
Per Capita Gross Emissions (Mt)	45	46	42	43
Per Capita Net Emissions (Mt)	31	34	32	34

These different rates of rate growth by decade can be explained by looking more closely at changes by sector, as shown in Figure D-4.

[11] The numbers in this table reflect a minor update to the original draft inventory and forecast report. A reporting error for coal-based electricity production, whereby coal-based electricity production was held flat 2018-2020, was found and fixed. The net effect is to increase emissions by 0.7 MMtCO2 in 2020 emissions.

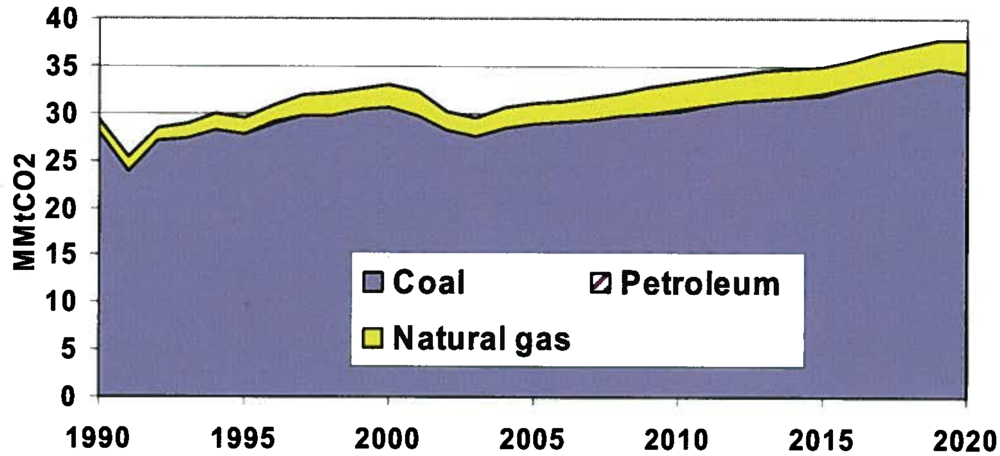
Figure D-4. Contributions to Emissions Growth, 1990-2020: Reference Case Projections (MMTCO2e)



As shown, electricity production emissions grew significantly from 1990 to 2000, as existing coal plants increased production and two new power plants came on line.[12] The year 2000 was also the time of the Western power crunch, where drought conditions on the West Coast, and other market factors led to increase demands for power on the Western grid system. Electricity production has since declined, and only recently returned to 2000 levels. With much of new electricity capacity this decade expected to come from natural gas and wind facilities, growth in statewide electricity emissions is likely to be limited. However, during the 2010-2020 period, with gas prices rising and several new coal plants being proposed, electricity emissions could rise rapidly again, as illustrated in Figure D-5 below.

[12] Increased generation from existing plants accounted for 90% of the increase in emissions from 1990 to 2000. Generation from the Four Corners coal plant did not change significantly, however generation at the San Juan coal plant increased by 33%, Escalante generation increased by 20%, and Rio Grande generation almost doubled. The Delta Person plant came on-line in 2000 (150MW) and the Milagro cogeneration unit in 1996 (61 MW). Note that CO2 emissions from biomass-fired combustion are not counted as net GHG emissions, consistent with USEPA and UNFCCC practices. To the extent that use of biomass energy leads to changes in carbon stocks in farms and forests, these standard methods suggest that this should be captured in forest and land use accounting.

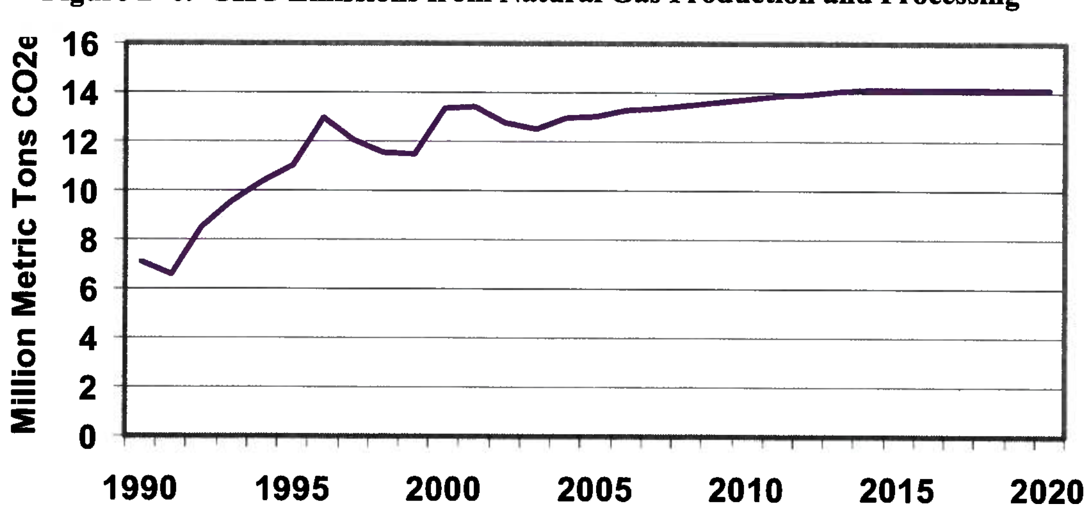
Figure D-5. CO2 Emissions from Electricity Production in New Mexico, by Fuel Source



Fossil fuel industry emissions grew rapidly in the 1990s with total natural gas production rising from 1015 billion cubic feet in 1990 to 1802 billion cubic feet in 2000. Natural gas production has dropped slightly since 2000. The future of New Mexico natural gas and oil production is highly uncertain, dependent on global price trends, discovery of new reserves, and other factors. For projection purposes, we assume that new reserves will be found and exploited such that recent production levels of oil and gas will be maintained.[13]

The implication of this forecast in terms of GHG emissions is illustrated in Figure D-6 below. This chart shows GHG emissions from the natural gas production and processing stages, the principal emissions sources for the oil and gas industry, and those most likely to be affected by future changes in production. GHG emissions from gas production and processing activities remain relatively constant from 2003 onward, with a slight increase owing to the increasing concentration of CO2 over time in coalbed methane production.

Figure D-6. GHG Emissions from Natural Gas Production and Processing



[13] The Energy Supply Technical Working Group reviewed and affirmed this assumption for projection purposes.

As Figure D-4 shows, the transportation sector is expected to be the leading source of overall GHG emissions growth from 2000 onward. Under the assumptions described in the transportation section (Attachment D-3), increasing diesel use for freight transport is projected to account for nearly half of this growth (3.7 MMtCO2e from 2000 to 2020). Increasing gasoline use would account for nearly as much growth (3.5 MMtCO2e), driven largely by State population growth, while rising jet fuel use would account for the remainder (0.8 MMtCO2e).

Other key sources of emissions growth include direct use of fuels in the residential, commercial, and non-fossil fuel industrial sectors, the switch to use of HFCs as substitutes for ozone-depleting substances, and methane emissions from dairy herds.

Consumption vs. Production-Based Emissions

As noted, New Mexico's emissions are well above the national average largely because of coal-based electricity generation and natural gas production activities, a significant fraction of which meets needs in other states. This situation raises an important question with respect to how these emissions should be addressed from an accounting and policy basis. In other words, should states focus on: a) all emissions produced within the State (*production-based emissions*), or b) the emissions associated with production of electricity, natural gas, and/or other energy-intensive products consumed within the State (consumption-based emissions).

Reporting production-based emissions has the advantages of simplicity and consistency with typical inventory methods. If used for policy purposes, e.g. for setting emission reduction goals and tracking progress in meeting them, production-based reporting will account for changes in emissions resulting from new in-state power plants or gas production facilities, even if such facilities are built largely to serve out-of-state consumption. Conversely, future declines in natural gas production, due for example to the depletion of gas reserves as noted, could lead to significant reductions in reported State emissions related to gas production activities. Such changes in the State's reported emissions could be very significant, and but may also be rather difficult to predict or manage. Furthermore, one could argue that these changes do not reflect "real" emissions changes, if electricity or gas consumers would otherwise source their electricity or gas from similar sources in other states or countries.

In contrast, reporting consumption-based GHG emissions can be more complex from an accounting perspective. However, the consumption-based approach may also better reflect the emissions (and emissions reductions) associated with consuming activities occurring within the State, particularly with respect to electricity use (and efficiency improvements), and is thus may be useful in a policy context. Under this approach, emissions associated with electricity exported to other states would need to be covered in those states' accounts in order to avoid double counting or exclusions. (Indeed, California, Oregon, and Washington are currently considering such an approach, as noted in Attachment D-1.) The consumption-based approach also leads to projections that are likely to be less volatile (subject to major changes), and future GHG emissions are perhaps more directly influenced by state-based policy strategies such as energy efficiency on overall emissions. However, as described in the electricity section (Attachment D-1), developing a robust tracking system for a consumption-based approach could be rather challenging.

For this inventory, we prepared simplified consumption-based estimates for the electricity sector. (A consumption-based approach for fossil fuel production activities was considered but ultimately rejected). For the electricity sector, we estimated the ratio of in-State consumption to total production, and applied this ratio to the total GHG emissions from the sector. (See Table D-4) While this method may not precisely reflect the sources of electricity used to meet in-state demands, it does provide a rough guide.

The result of these calculations is shown in Table D-2 below. Emissions related to electricity use are about 30-40% lower than for electricity production, reflecting the fact that the State produces about 30-40% more electricity than it needs for its own use.

Table D-2. New Mexico GHG Emissions, Reference Case – Consumption Based[14]

(Million Metric Tons CO2e)	1990	2000	2010	2020
Energy	**48.9**	**60.7**	**67.8**	**79.7**
Electricity Use	15.8	19.7	21.4	26.8
Transportation Fuel Use	11.0	14.2	17.6	22.3
Fossil Fuel Industry	15.2	19.5	20.3	20.7
Res/Comm/Other Ind. Fuel Use	7.0	7.3	8.5	9.9
Other	**5.9**	**8.7**	**9.7**	**10.8**
Industrial Processes	0.5	1.5	2.0	2.8
Agriculture	4.5	6.0	6.4	6.7
Waste Management	0.8	1.2	1.4	1.2
Gross Emissions	**54.8**	**69.5**	**77.5**	**90.4**
change relative to 1990		27%	41%	65%
change relative to 2000			12%	30%
Forestry and Land Use	***-20.9***	***-20.9***	***-20.9***	***-20.9***
Net Emissions (incl. forestry)	**33.9**	**48.6**	**56.6**	**69.5**
change relative to 1990		43%	67%	105%
change relative to 2000			17%	43%
Per Capita Gross Emissions	36	38	37	38
Per Capita Net Emissions	22	27	27	29

Key Uncertainties and Next Steps

Efforts were made to resolve key data gaps and uncertainties in the inventory and projections. Key tasks, among others, included the incorporation of anticipated actions and policies (efficiency programs, voluntary actions such as those of the oil and gas industries through the USEPA GasStar program, etc.), a better understanding of the electricity generation sources currently used to meet New Mexico loads (in collaboration with State utilities), closer review of the many sources of oil and gas sector emissions, and review and revision of key drivers such as the electricity growth rates and future oil and gas production that will be major determinants of New Mexico's future GHG emissions (See Table D-3). These growth rates are driven by uncertain economic, demographic, and land use trends (including growth patterns and transportation system impacts), all of which deserved close review and discussion.

[14] The numbers in this table reflect a significant technical change to the original draft inventory and forecast report that used a consumption-based approach for the fossil fuel industry. Late in the process, the CCAG approved production-based approach to this industry. As an example of the consequent changes, this increased the 2020 projection for the industry by 14 MMT and this change flowed through to energy total, gross emissions total, etc.

Table 3. Key Annual Growth Rates, Historical and Projected

	Historical 1990-2000	Projected 2000-2020	Sources/Uses
Population*	1.8%	1.4%	New Mexico Department of Labor, 2004. New Mexico Annual Social and Economic Indicators
Employment*	2.4%	2.1%	
Electricity sales	3.1%	2.5% from 2002 on	EIA SEDS for historic, projections based on EMNRD input.
Electricity production	1.6%	2.2% from 2004 on	Based roughly on AEO 2005 for the region; subject to very large uncertainties
Personal Vehicle Miles Traveled*	2.9%	1.9%	New Mexico 2025 Statewide Multimodal Transportation Plan (historical from FHWA Transportation Statistics)
Freight Vehicle Miles Traveled*	6.9%	3.6%	

* Population, employment and VMT projections for New Mexico were used together with US DOE's Annual Energy Outlook 2005 projections of changes in fuel use on a per capita, per employee, and per VMT, as relevant for each sector. For instance, growth in New Mexico residential natural gas use is calculated as the New Mexico population growth times the change in per capita New Mexico natural gas use for the Mountain region. New Mexico population growth is also used as the driver of growth in cement production, soda ash consumption, solid waste generation, and wastewater generation.

In addition, the following three areas are subject to considerable uncertainty, not simply because the future is hard to predict, but because of data availability and scientific understanding:

- **Oil and gas sector emissions:** As noted above, the sheer number and diversity of different GHG-emitting activities, combined with the fact that GHG emissions are typically unmonitored, means that there is significant uncertainty with regard to emission levels. Local estimates of field gas use and provided by NMOGA suggest the top-down estimates of natural gas production-related emissions provided here (based on national average emission rates) may be low. Furthermore, CO_2 emissions that may occur as the result of CO_2 mining and use for enhanced oil recovery could be significant, but have not been estimated. Further analysis of emissions from activities in all of the State's principal gas and oil basins, as well as of emissions from transmission and distribution sources could help to resolve some of these uncertainties. Given the large emission reduction potential that may exist in these sectors, such efforts could be quite valuable.

- **Terrestrial carbon emissions and sinks:** The net forest and land use sequestration estimates noted above are based on recent improvements to US Forest Service carbon stock inventory data but do not fully address all issues that impact the quality of the emission estimates.

  For instance, US Forest Service assessments only cover the parts of the State that the US Forest Service defines as forest, which represented 27% of the total State land area in

1997. Between the dates of the two most recent forest inventories, 1987 and 1997, the Forest Service changed its technical definition of forestland from minimum of 10% canopy cover to a minimum 5% cover. As a result, later years in the inventory period report increased carbon stocks due to this definitional change. According the US Forest Service contacts, there is no ability on their part to normalize the forested acreage to a single definition (either 5% or 10%). However, the overall impact of the change in forest definition is expected to be small in comparison to other forest carbon modeling issues, including a lack of carbon measurements in pinon/juniper systems (an important land cover type in NM).

To the extent that rangelands may sequester or emit carbon, while small on a per acre basis, they may be quite significant at the State level. This is due to the large amount of rangeland cover present in NM. The current inventory does not include rangeland carbon sequestration estimates. Additional research in this area is recommended.

Another data limitation arises from the lack of inventory data since 1997. Due to funding constraints in New Mexico, US Forest Service data from the Forest Inventory Analysis (FIA) are not available from 1997 onward. As a result, biomass reductions from wildfires and forest health problems, or other carbon stock changes since that time, are not reflected in the estimates provided here. These changes need to be clarified to provide accurate forest carbon projections. For the time being, forest carbon projections are based solely on a linear extrapolation of the 1987-1997 period for which data are available, and do not factor in the effects of potential future changes in forest health, productivity and use.

- **Black carbon and other aerosol emissions.** Emissions of aerosols, particularly black carbon from fossil fuel and biomass combustion, could have potential significant impacts in terms of radiative forcing (i.e. climate impacts). Methodologies for conversion of black carbon mass estimates and projections to global warming potential involve significant uncertainty at present. This inventory and forecast does not attempt to estimate these other potential contributors to climate change.

Table D-4. Simplified Calculation of Consumption-Basis Emissions for Electricity Sector

	1990	2000	2010	2020	Units
Electricity					
Electricity Produced (net of RPS)	29	34	37	44	TWh
In-State Electricity Needs (net of RPS)	15	20	24	30	TWh
in-state share	*54%*	*59%*	*64%*	*69%*	
Electricity Production Emissions	29	33	33	39	MMtCO2e
Consumption-Basis Emissions	16	20	21	27	MMtCO2e

Table D-5. Reference Case, Production-Based GHG Emissions, Detailed Results

(Million Metric Tons CO2e)	1990	2000	2010	2020	Explanatory Notes for Projections
Electricity Production	**29.5**	**33.2**	**33.3**	**38.8**	
Coal	28.0	30.7	30.4	35.5	See electric sector assumptions
Natural Gas	1.4	2.5	2.9	3.2	in Attachment D-1
Oil	0.0	0.0	0.0	0.0	
Res/Comm/Non-Fossil Ind (RCI)	**7.0**	**7.3**	**8.5**	**9.9**	
Coal	0.1	0.2	0.2	0.2	Based on USDOE regional projections
Natural Gas	3.8	4.6	4.5	5.4	Based on USDOE regional projections
Oil	3.1	2.5	3.8	4.3	Based on USDOE regional projections
Wood (CH4 and N2O)	0.0	0.0	0.0	0.0	Assumes (for now) no change after 2003
Transportation	**11.0**	**14.2**	**17.6**	**22.3**	
On-road Gasoline	7.2	8.7	10.2	12.2	VMT from NMDOT, constant energy/VMT
On-road Diesel	2.5	4.2	5.6	7.9	VMT from NMDOT, constant energy/VMT
Natural Gas, LPG, Other	0.1	0.1	0.1	0.1	Based on USDOE regional projections
Jet Fuel and Aviation Gasoline	1.2	1.2	1.6	2.0	Based on USDOE regional projections
Fossil Fuel Industry	**15.2**	**19.5**	**20.3**	**20.7**	
Natural Gas Industry	12.7	17.0	17.3	17.7	Assumes no change in state gas production
Oil Industry	2.3	2.3	2.3	2.3	Assumes no change in state oil production
Coal Mining (Methane)	0.2	0.2	0.7	0.7	Assumes no change after 2003
Industrial Processes	**0.5**	**1.5**	**2.0**	**2.8**	
ODS Substitutes	0.0	0.5	1.3	2.3	Based on national projections (State Dept.)
PFCs in Semi-conductor Ind.	0.1	0.5	0.2	0.1	Based on national projections (USEPA)
SF6 from Electric Utilities	0.2	0.1	0.1	0.0	Based on national projections (USEPA)
Cement & Other Industry	0.2	0.4	0.4	0.4	Assumes no change after 2003
Carbon Dioxide Consumption					not yet estimated
Waste Management	**0.8**	**1.2**	**1.4**	**1.2**	
Solid Waste Management	0.6	1.0	1.1	0.9	Based on national projections (State Dept.)
Wastewater Management	0.2	0.2	0.3	0.3	Increases with state population
Agriculture	**4.5**	**6.0**	**6.4**	**6.7**	
Manure Mgmt & Enteric Ferment. (CH4)	2.3	3.5	4.1	4.4	Dairy emissions grow with population
Agricultural Soils (N2O)	2.2	2.4	2.3	2.3	No changes projected
Total Gross Emissions	**68.5**	**82.9**	**89.4**	**102.4**	
Forestry and Land Use	**-20.9**	**-20.9**	**-20.9**	**-20.9**	
Net Emissions (incl. forestry)	**47.6**	**62.0**	**68.5**	**81.5**	

2. Approach

The principal goal of the inventory and reference case projections was to provide the State, stakeholders and technical work groups with a general understanding of New Mexico's historical, current and projected (expected) greenhouse gas emissions.

2.1 General Principles and Guidelines

A key part of this effort involves the establishment and use of a set of generally accepted accounting principles for evaluation of historical and projected GHG emissions, as follows:

- **Transparency:** We report data sources, methods, and key assumptions to provide open review and opportunities for additional revisions later based on stakeholder and technical work group input.

- **Consistency:** To the extent possible, the inventory and projections are designed to be externally consistent with current or likely future systems for state and national GHG emission reporting. We have used USEPA tools for state inventories and projections as a starting point. These initial estimates were then augmented to conform to local data and conditions, as informed by New Mexico-specific sources and experts.

- **Comprehensive Coverage of Gases, Sectors, State Activities, and Time Periods.** This analysis aims to comprehensively cover GHG emissions associated with activities in New Mexico. It covers all six greenhouse gases covered by US and other national inventories: carbon dioxide, (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs). Black carbon, organic carbon, and other potential GHG emission sources will be considered as data and methods allow.

- **Priority of Significant Emissions Sources:** In general, activities with relatively small emissions levels may not be reported in the same level of detail as other activities.

- **Priority of Existing State and Local Data Sources:** In gathering data and in cases where data sources may conflict, we place highest priority on local and state data and analyses, followed by regional sources, with national data used as defaults where necessary.

- **Presentation of Production-Based and Consumption-Based Emissions Estimates:** For all sources, we present emissions produced by in-state activities, which are referred to here as production-based emissions. For electricity, which is produced in amounts well in excess of New Mexico requirements, we also estimate consumption-based emissions, i.e. the emissions reasonably attributable to the consumption of electricity by consumers in New Mexico.

For electricity, consumption-based accounting, in principle, should reflect an understanding of the electricity sources used by New Mexico utilities to meet consumer demands. For this draft inventory, we take a simpler approach, estimating consumption-based emissions by multiplying total production-based emissions (from fuel combustion at all in-state power plants) times the fraction of total electricity produced (MWh) that would be needed to meet in-state electricity demands.

2.2 General Methodology

We prepared this analysis in close consultation with New Mexico agencies, in particular, the Department of Environment (NMED) staff. The overall goal of this effort is to provide simple and straightforward estimates, with an emphasis on robustness and transparency. As a result, we rely on straightforward spreadsheet analysis rather than detailed modeling.

In most cases, we follow the same approach to emissions accounting used by the US EPA in its national GHG emissions inventory[15] and its guidelines for states.[16] These inventory guidelines were developed based on the guidelines from the Intergovernmental Panel on Climate Change, the international organization responsible for developing coordinated methods for national greenhouse gas inventories.[17] The inventory methods provide flexibility to account for local conditions.

The electricity sector is the area in which we expand the US EPA inventory approach, by looking at consumption-based in addition to production-based emissions, as described above. We encouraged New Mexico stakeholders to closely consider the question of whether and how to count GHG emissions from exports of electricity produced in the State with respect to setting and tracking emissions. Stakeholders may also want to consider strategies that work together with neighboring states to reduce overall GHG emissions. A number of other accounting questions also need to be resolved, such as the treatment of transportation fuels used out of state and for international travel.

[15] US EPA, Feb 2005. *Draft Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2003.* http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2005.html.
[16] http://yosemite.epa.gov/oar/globalwarming.nsf/content/EmissionsStateInventoryGuidance.html
[17] http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.htm

Table D-6. Key Sources for Data, Inventory Methods and Projection Growth Rates

Source	Information provided	Use of Information in this Analysis
US EPA State Greenhouse Gas Inventory Tool (SGIT)	EPA SGIT is a collection of linked spreadsheets designed to help users develop state GHG inventories. EPA SGIT contains default data for each state for most of the information required for an inventory.	Where not indicated otherwise, SGIT is used to calculate emissions from industrial processes, agriculture and forestry, and waste. We use SGIT emission factors (CO2, CH4 and N2O per BTU consumed) to calculate energy use emissions.[18]
US DOE Energy Information Administration (EIA) State Energy Data System (SEDS)	EIA SEDS source provides energy use data in each state, annually to 2002.	EIA SEDS is the source for all energy use data except on-road gasoline and diesel consumption. Emission factors from EPA SGIT are used to calculate energy-related emissions.
US DOE Energy Information Administration Annual Energy Outlook 2005 (AEO2005)	EIA AEO2005 projects energy supply and demand for the US from 2005 to 2025. Energy consumption is estimated on a regional basis. New Mexico is included in the Mountain Census region (AZ, CO, ID, MT, NM, NV, UT, and WY)	EIA AEO2005 is used to project changes in per capita (residential), per employee (commercial/industrial). (See Table 3)
New Mexico Department of Transportation (NMDOT)	NMDOT reports on-road gasoline and diesel consumption based on calculations from tax revenue.	NMDOT provides data for gasoline and diesel consumption.
NMDOT's New Mexico 2025 Statewide Multimodal Transportation Plan	The New Mexico 2025 analysis projects transportation demand.	This report is the source vehicle mileage growth rates in the transportation sector.

[18] We did not use the EPA SGIT tool directly to calculate emissions from energy use because the data in the tool has not been updated to the most recent energy consumption data. By calculating GHG emissions directly from energy use multiplied by the emissions factors from SGIT, we are able to use locally sourced energy data, such as NMDOT gasoline and diesel sales data.

Attachment D-1. Electricity Use and Supply[19]

New Mexico is an important supplier of electricity to the Western US. The State's power plants have historically produced more electricity than consumed in the State, and have exported significant amounts of electricity to Arizona, California, and other Western states. In 2000, for instance, New Mexico power plants produced 36% more electricity than needed for in-state use.[20] The New Mexico electricity sector is also dominated by coal, which accounts for nearly 90% of all electricity generated in recent years. Coal-fired power plants produce as much as twice the CO2 emissions per kilowatt-hour of electricity as natural gas-fired power plants. As a result of these factors, New Mexico power plants are the largest source of GHG emissions in the State.

As noted earlier, one of the key questions for the State to consider is how to treat GHG emissions that are produced to serve needs outside the State. In other words, should the State consider the GHG emissions associated with the State's electricity consumption or its electricity production, or some combination of the two? Since this question still needs to be resolved, this section examines electricity-related emissions from both a production and consumption basis.

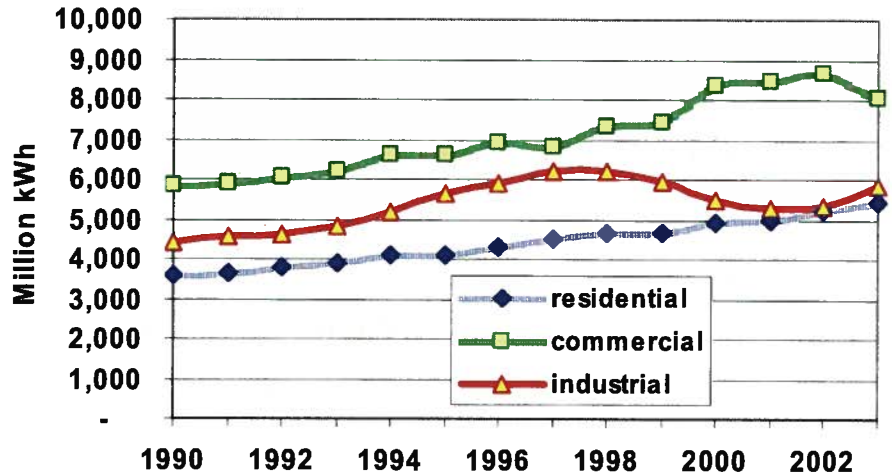
This Attachment describes New Mexico's electric sector in terms of consumption and production, including the assumptions used to develop the reference case projections. It then describes New Mexico's electricity trade and potential approaches for allocating GHG emissions for the purpose of determining the State's inventory and reference case. Finally, key assumptions and results are summarized.

Electricity Consumption

At about 10,000 kWh/capita (2003 data), New Mexico has relatively low electricity consumption per capita. By way of comparison, the per capita consumption for the US is 12,000 kWh per year, with California averaging at 7,000 kWh, Arizona at 8,000 kWh, and Texas at 15,000 kWh. As shown in Figure D-7, the commercial sector has the greatest electricity consumption in New Mexico, with strong growth from 1990, except for a slight decrease in 2003. The industrial sector grew strongly from 1990 to 1997 then dropped through 2001 with some increase in the last couple years.[21] The residential sector, has the lowest consumption among sectors, but is growing the most rapidly, averaging 3.3% annually from 1990 to 2003, compared with population growth of 1.7%.

[19] The Energy Supply Technical Working Group reviewed and accepted the assumptions and results shown in this section.
[20] EGRID2002 software (US EPA http://www.epa.gov/cleanenergy/egrid/whatis.htm)
[21] Electricity consumption figures here only include purchased electricity, and do not include electricity generated and consumed internally by specific industries, such as mining.

Figure D-7. Electricity Consumption by Sector, 1990-2003



The States' four investor-owned utilities serve approximately 70% of the customers, and 70% of load, as illustrated in Table D-7. The State's 20 rural electric cooperatives serve 22% of customers, although they service about 85% of the State's land area. There are seven municipal electric utilities serving the remaining eight percent of the State's electric customers. (EMNRD, 2003)

Table D-7. Retail Electricity Sales by New Mexico Utilities (2002)

	2002 GWh
Top 5 Utilities, ranked by retail sales	
Public Service Company of New Mexico	7,407
Southwestern Public Service	3,443
El Paso Electric Company	1,355
City of Farmington	1,043
Texas - New Mexico Power Company	1,018
Total of above utilities	14,266
Total, all New Mexico	19,207

Source: EIA state electricity profiles

Overall, total electricity consumption grew at an average annual rate of 2.6% from 1990 to 2003, about half the rate of gross state product growth (5% per year).[22] For initial projections, future electricity consumption is projected to grow at a rate of 2.5% per year through 2020, compared with expected population growth of 1.3% per year.[23]

[22] Gross State Product growth from Bureau of Economic Analysis, www.bea.doc.gov/bea/regional/gsp/default.cfm.
[23] This growth rate was suggested by EMNRD staff, based on growth rates discussed by electricity providers of 1.5%-2% per year for the utilities and 3.6% per year from co-operatives.

Electricity Generation –New Mexico's Power Plants

As mentioned above and displayed in Figure D-8 below, coal figures prominently in electricity generation and GHG emissions from power plants in New Mexico. Table D-8, which reports the emissions from the largest plants from 1995 to 2003, shows that two plants Four Corners and San Juan account for the vast majority of emissions. As explained further in the electricity trade section below, both of these plants are partly owned by utilities outside of New Mexico (only 14% of Four Corners and about 54% of San Juan capacity are owned by New Mexico utilities). While some of the electricity generated by these plants serves needs for New Mexico residents and businesses, much is used to serve those outside the State. Conversely, New Mexico utilities own shares of plants in other states.[24]

Figure D-8. Electricity Generation and CO2 Emissions from New Mexico Power Plants, 2002

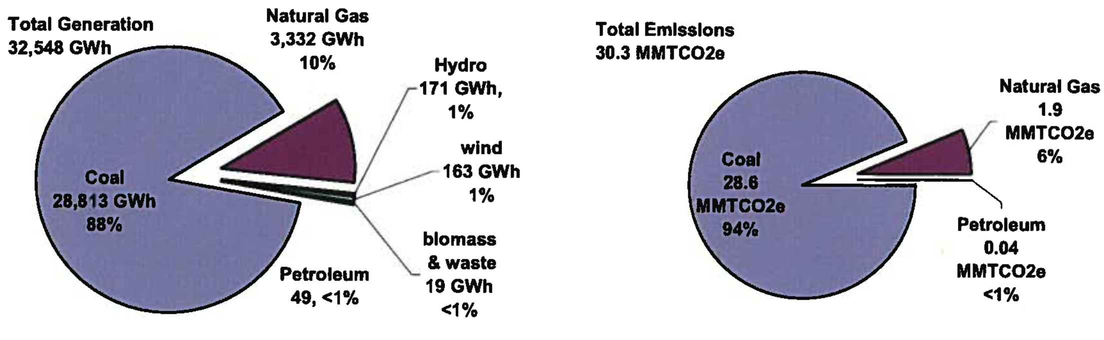


Table D-8. CO2 Emissions from Individual New Mexico Power Plants, 1995-2003

(Million Metric Tons CO2e)	1995	1996	1997	1998	1999	2000	2001	2002	2003
Four Corners Steam	15.7	14.5	14.5	15.3	15.9	15.4	15.6	13.5	14.8
San Juan	11.0	12.7	13.2	13.0	12.5	13.2	12.5	13.1	11.1
Prewitt Escalante	1.2	1.8	2.1	1.5	2.1	2.0	1.7	1.6	1.7
Rio Grande	0.6	0.5	0.5	0.6	0.5	0.6	0.5	0.5	0.5
Maddox	0.3	0.3	0.3	0.4	0.3	0.4	0.4	0.3	0.3
Other units	0.9	1.0	1.3	1.4	1.5	1.6	1.7	1.2	1.2
Total	**29.6**	**30.8**	**31.9**	**32.2**	**32.7**	**33.1**	**32.4**	**30.2**	**29.5**

Source: USEPA Clean Air Markets database for named plants (http://cfpub.epa.gov/index.cfm). Other units calculated from fuel use data provided by US DOE EIA.

Future Generation and Emissions

[24] Emissions from the 5 largest power plants were obtained from the EPA Clean Air Markets database, http://cfpub.epa.gov/gdm/index.cfm. Since data from the EPA Clean Air Markets Division do not include plants under 25MW, supplemental data were required for a complete emissions estimate. Emissions for all remaining power plants were calculated by using the energy consumption for the remaining plants multiplied by EPA emissions factors by fuel, accounting for combustion efficiency and changes in average carbon content of coal over time.

Estimating future generation and GHG emissions from New Mexico power plants requires a notion of new power plant additions and production levels from new and existing power plants. There are, of course, large uncertainties here, especially related to the timing and nature of new power plant construction.

Table D-9 lists the characteristics of recent and several proposed plants. As shown, there are proposals on the drawing boards for over 2500 MW of new power plants, most of them coal-based. If built and fully operated, these power plants could produce over 15 MMtCO2 in GHG emissions. However, the future mix of plants in New Mexico remains uncertain as the trends in type of new builds are influenced by many factors:

- The most recent fossil-fuel plants have been natural gas-fired, however there are concerns that natural gas prices may increase over the next decade, which could cause a trend towards more coal-dominated.

- Several coal plants have been proposed – taking advantage of the current price advantage for coal plus support from federal government for clean coal – but construction could be limited by air quality requirements.

- Some proposed plants have applied for permits, including natural gas and biomass facilities. Permitted plants are not always built. Actual implementation depends on market conditions, adequate financing, and other factors. Permits are only valid for specified timeframe; if construction does not begin during this period, the developer must resubmit the application, and it may or may not be granted again depending on emerging conditions.

- In the last few years several wind plants have been developed and others have been proposed. These developments reflect the declining cost of wind plants, federal and state incentives (production tax credit and renewable portfolio standard), and increased customer demand for "green" electricity.

Table D-9. Recently Constructed, Approved and Proposed Plants in New Mexico

	Plant Name	Fuel	Status	Capacity MW	Expected Annual generation GWh	Emissions MMTCO2e	Notes
Wind Plants	New Mexico Wind Energy Center	wind	On-line Oct 2003	200	594	0	used by PNM to meet RPS
	Caprock Cielo/Xcel	wind	80 MW on-line in 2004/2005	80	299	0	Used by Southwestern to meet RPS and customer green electricity choice
	San Juan Mesa	wind	expected on-line by December 2005	120	368	0	Used by Southwestern to meet RPS and customer green electricity choice
New plants	Afton[1]	Natural gas	On-line 2002	135	14	0.01	Designed by PNM for Western wholesale market
	Bluffview[2]	Natural gas	On-line 2005	60	447	0.16	City of Farmington
	Lordsburg[1]	Natural gas	On-line 2002	80	65	0.04	Designed by PNM for peaking power
	Luna[2]	Natural gas	under-construction 2006	570	4,244	1.50	Recently purchased by consortium including PNM
	Pyramid[2]	Natural gas	On-line 2003	160	1,191	0.42	Pyramid assists in serving Tri-State's southern system loads and provides backup generation.
Proposed plants	Mustang[2]	coal	An air quality permit application accepted.	300	2,234	1.85	
	Desert Rock Energy Project[2]	coal		1500	11,169	9.23	Sithe Global Power's has proposed a 1500 MW of new coal-fired electrical production to be located on Navajo lands in the 4 Corners
	BHP Billiton[2]	coal		550	4,095	3.38	BHP Billiton's subsidiary Chaco Valley Energy submitted a permit application for a power plant that would operate if the Desert Rock proposal (see above) does not go through.
	Valencia Energy[2]	Natural gas		337	2,509	0.89	This project has received permits but not broken ground
	Northeast New Mexico Biomass	biomass		35	261		

Sources: New Mexico Environment, Air Quality website, discussions with Ted Schooley and Sam Speaker (NMED), Donald Groves (PNM), City of Farmington utility, also Western Resource Advocates website (http://westernresources.org/energy/newmcoal.html)

Notes:

Generation for wind plants is based on information from utility websites. Generation for new fossil fuel plants is estimated using an 85% capacity factor.

1. Emissions are estimated by average 2003 and preliminary 2004 data from USEPA's Clean Air Markets division.
2. Emissions are based on USDOE Annual Energy Outlook assumptions

Given these uncertainties, and a diversity of perspectives by actors within the electricity sector, it is particularly challenging to develop a "reference case" projection for the most likely development of New Mexico's electricity sector. Therefore, to develop an initial projection, simple assumptions were made, relying to the extent possible on widely-reviewed modeling assessments. The reference case projections assume:

- Total generation in New Mexico grows at the regional growth rates forecast by the National Energy Modeling System (NEMS) developed by the US Energy Information Administration for projecting US energy supply and demand to 2025 in the US DOE's Annual Energy Outlook 2005.

- Generation from existing coal plants is based on Western Regional Air Partnership (WRAP) analyses[25]; generation from all other plants is assumed to remain at 2003 levels. Existing plants include those on-line or expected on-line by the end of 2005.

- Generation from new power plants provides the remainder of this growth. New Mexico utilities are expected to build renewables as needed to comply with the State *Renewable Portfolio Standard; it* is assumed that wind generation will dominate these renewable power additions, per utility plans.[26] The remainder of generation growth is expected to be supplied a mix of 80% coal and 20% natural gas; this assumptions is based on review of studies noted in Table D-10 below.

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Electricity Trade and Allocation of GHG emissions

New Mexico is part of the interconnected Western Electricity Coordinating Council (WECC) region - a vast and diverse area covering 1.8 million square miles and extending from Canada through Mexico, including all or portions of 14 western states. The inter-connected region allows electricity generators and consumers to buy and sell electricity across regions, taking advantage of the range of resources and markets. Electricity generated by any single plant enters the interconnected grid and may contribute to meeting demand throughout much of the region, depending on sufficient transmission capacity. Thus it is challenging to define which emissions should be allocated to New Mexico, and secondly in estimating these emissions both historically and into the future. Some utilities track and report electricity sales to meet consumer demand by fuel source and plant type; however, tracing sales to individual power plants may not be possible.

In 2003, electricity consumption in New Mexico was 19.3 TWh while electricity generation was 32.5 TWh. Also, as mentioned above, New Mexico utilities own less than 32% of the two largest plants in the State (San Juan and Four Corners). Thus a significant portion of the electricity generated and economic benefits may serve consumers and investors in other states. Similarly, all of the largest utilities (except City of Farmington) own shares in plants outside of the State (e.g. Public Service Company of New Mexico (PNM) owns 10% of Palo Verde nuclear plant).

Since almost all states are part of regional trading grids, many states that have developed GHG inventories have grappled with this problem and several approaches have been developed to allocate GHG emissions from the electric sector to individual states for inventories.
In many ways the simplest approach is *production-based* – emissions from power plants within the State are included in the state's inventory. The data for this estimate are publicly available and unambiguous. However, this approach is problematic for states that import or export

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[25] From WRAP Market Trading Forum, Grand Canyon Visibility Transport Commission, Emission Inventory Reconciliation v4_01 spreadsheet
http://www.wrapair.org/forums/mtf/documents/group_reports/TechSupp/SO2Tech.htm

[26] http://www.pnm.com/regulatory/pdf_electricity/renewable_stip_05.pdf
http://www.epelectric.com/internetsite/renewable.nsf/by+subject/Transitional+Procurement+Plan+Application/$file/Procurement+Plan+Application.pdf?OpenElement
http://www.xcelenergy.com/docs/corpcomm/NM-PortfolioReportProcurementPlan.pdf

significant amounts of electricity. Because of the State's large exports, under a production-based approach New Mexico residents would be taking responsibility for emissions that they have limited ability to mitigate and that provide limited benefit to the State.

An alternative is to estimate *consumption-based* or *load-based* GHG emissions, corresponding to the emissions associated with electricity consumed in the State. The load-based approach is currently being considered by states that import significant amounts of electricity, such as California, Oregon, and Washington.[27] By accounting for emissions from imported electricity, states can account for increases or decreases in fossil-fuel consumed in power plants outside of the State, due to demand growth, efficiency programs, and other actions in the State. The difficulty with this approach is properly accounting for the emissions from imports and exports. Since the electricity flowing in or out of New Mexico is a mix of all plants generating on the inter-connected grid, it is impossible to physically track the electrons.

The approach taken in this initial inventory is a simplification of the consumption-based approach. This approach, which one could term "*Net-Consumption-based*", estimates consumption-based emissions as in-state (production-based) emissions times the ratio of total in-state electricity consumption to in-state generation (net of losses). For example, in 2003, New Mexico residents and business consumed 66% (19.3 TWh) of total in-state generation (32.5 TWh) net of transmission and distribution losses (10%).

This method does not account for differences in the type of electricity that is imported or exported from the State, and as such, it provides a simple method for reflecting the emissions impacts of electricity consumption in the State. More sophisticated methods – e.g. based on individual utility information on resources used to meet loads – can be considered for further improvements to this approach.

Summary of Assumptions and Reference Case Projections

As noted, projecting generation sources, sales, and emissions for the electric sector out to 2020 requires a number of key assumptions, including economic and demographic activity, changes in electricity-using technologies, regional markets for electricity (and competitiveness of various technologies and locations), access to transmission and distribution, the retirement of existing generation plants, the response to changing fuel prices, and the fuel/technology mix of new generation plants. The key assumptions described above are summarized in Table D-10.

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[27] See for example, the reports of the Puget Sound Climate Protection Advisory Committee (http://www.pscleanair.org/specprog/globclim/), the Oregon Governor's Advisory Group On Global Warming http://egov.oregon.gov/ENERGY/GBLWRM/Strategy.shtml, and the California Climate Change Advisory Committee, Policy Options for Reducing Greenhouse Gas Emissions From Power Imports - Draft Consultant Report, http://www.energy.ca.gov/2005publications/CEC-600-2005-010/CEC-600-2005-010-D.PDF

Table D-10. Key Assumptions and Methods for Electricity Projections

Electricity sales	2.5% annual growth rate, based on input from EMNRD
Electricity generation	2.5% annual growth is assumed to match sales growth from 2004-2010. 2% annual growth is assumed from 2011 to2020, based on regional growth in EIA AEO2005 (AZ, NM and southern NV)
Transmission and Distribution losses	10% losses are assumed, based on average statewide losses, 1994-2000, (data from EPA Emission & Generation Resource Integrated Database[28])
New Renewable Generation Sources	Public Service of New Mexico and Southwestern Public Service and El Paso Electric Company follow procurement plans filed in 2004 (resulting in new wind plants that will exceed the RPS requirements until 2010). After 2010, new renewable plant builds are assumed to sufficient to meet but not exceed RPS. For other utilities, no additional new renewables are assumed.
New Non-Renewable Generation Sources (2004-2010)	From 2006-2010, the assumed mix is 20% coal and 80% natural gas (MWh basis), based on the dominance of natural gas among plants currently under construction.
New Non-Renewable Generation Sources (2011-2020)	For 2011 to 2020, the assumed mix is 80% coal and 20% natural gas (MWh basis), based on a review of studies including EIA AEO2005, ICF/WRAP 2002, and others.[29]
Heat Rates	The assumed heat rates for new gas and coal generation are 7000 Btu/kWh and 9000 Btu/kWh, respectively, based on estimates used in similar analyses.[30]
Operation of Existing Facilities	Current sources of coal-based electricity generation increase output according to analysis completed for the WRAP.[31]

Figure D-9 shows historical sources of electricity generation in the State by fuel source, along with projections to the year 2020 based on the assumptions described above. Natural gas generation has grown considerably during the past decade, while coal and hydro generation have stayed relatively constant. The first major wind project, New Mexico Wind Energy Center, came on-line in 2003 and wind generation is expected to grow in the next couple years as utilities complete plants built to meet renewable portfolio standard. Based on the above assumptions for new generation, natural gas continues to dominate new generation through 2010, at which point coal assumes an increasing market share, reflecting assumptions that natural gas prices will continue to rise.

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[28] http://www.epa.gov/cleanenergy/egrid/index.htm

[29] Western Resource Advocates, 2004. *A Balanced Energy Plan for the Interior West.* http://www.westernresourceadvocates.org/energy/bep.html and ICF 2002. *Economic Assessment of Implementing the 10/20 Goals and Energy Efficiency Recommendations* (prepared for Western Regional Air Partnership).

[30] See, for instance, the Oregon Governor's Advisory Group On Global Warming http://egov.oregon.gov/ENERGY/GBLWRM/Strategy.shtml

[31] See emissions reconciliation documentation for 2000/2001 at http://www.wrapair.org/forums/ mtf/documents/group_reports/TechSupp/SO2Tech.htm. The results of this analysis are referenced in subsequent WRAP analyses, including *An Assessment of Critical Mass for the Regional SO_2 Trading Program* (ICF 2002)

Figure D-9. Electricity Generated By New Mexico Power Plants, 1990-2020

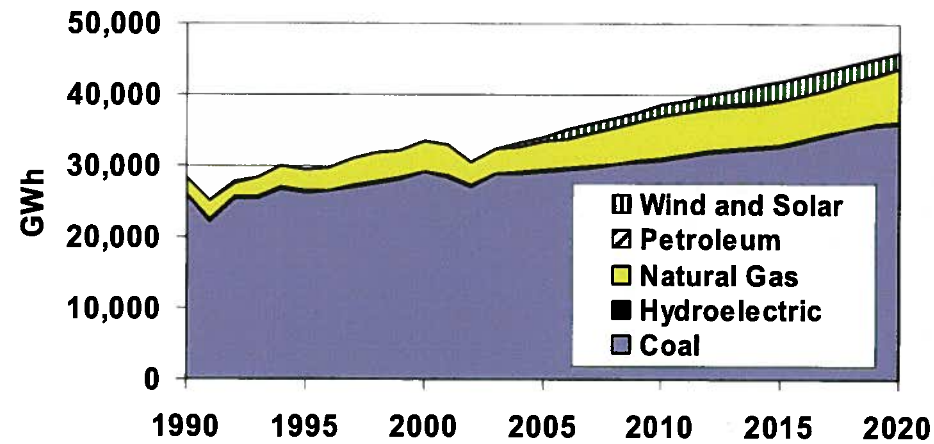


Figure D-10 illustrates the GHG emissions associated with the mix of electricity generation shown in Figure D-9. From 2005 to 2020, the emission from New Mexico electricity generation are projected to grow at 1.3% per year, slower than the 2.5% growth in electricity generation, due to increased natural gas generation and assumed increases in energy efficiency of new coal plants that are built after 2010 (compared to efficiency of existing units today). As a result, the emission intensity (emissions per MWh) of New Mexico electricity is expected to decline by about 10% (from 0.91 MTCO2/MWh in 2000 to 0.82 MTCO2/MWh in 2020).

Figure D-10. CO_2 Emissions Associated with Electricity Production (Production-Basis), Includes Exports

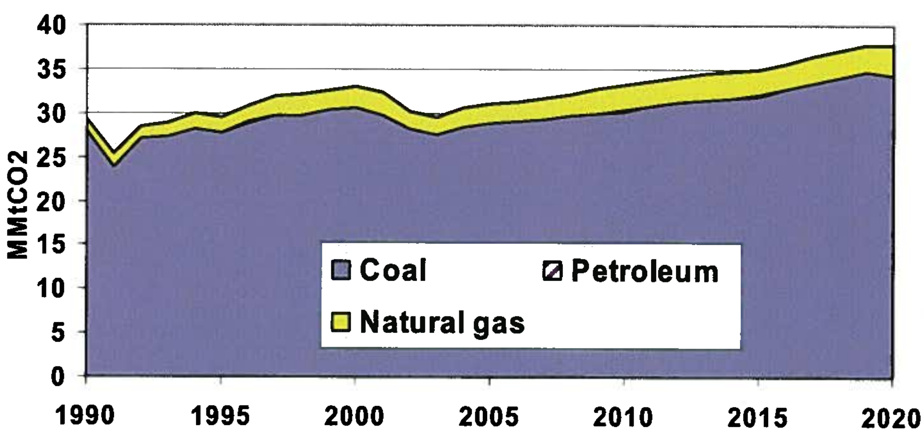
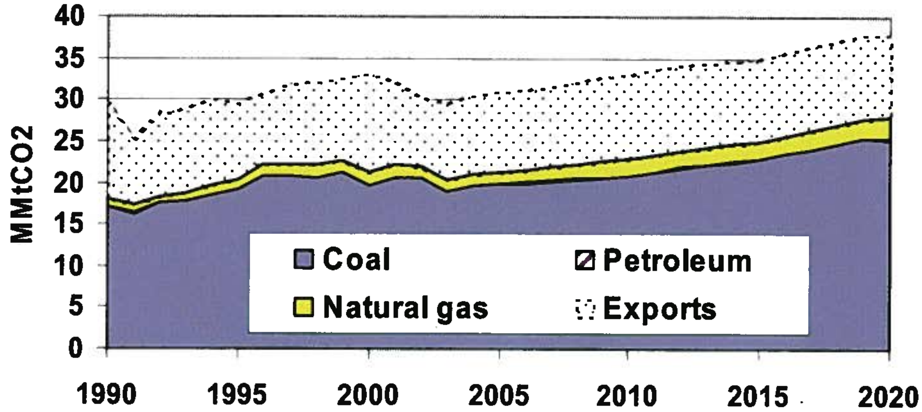


Figure D-11 shows the "net-consumption-basis" emissions from 1990 to 2020. Total emissions match those shown in the previous "production-basis" chart; here, however, a significant fraction is attributed to net electricity exports as shown in the top area.

Figure D-11. CO_2 Emissions Associated with Electricity Use (Consumption-Basis) and Exports



Key uncertaintie

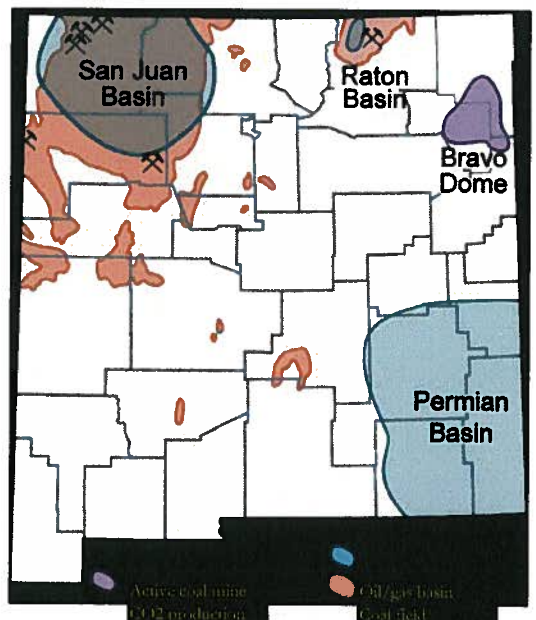
As noted above, these estimates are subject to a number of uncertainties. Perhaps the uncertainty with the most important implications for GHG emissions is the type, size, and number of power plants built in New Mexico between now and 2020. As noted above, there are also significant uncertainties associated with projecting electricity consumption in the State, as well as in the estimation of consumption-based electricity emissions (i.e. which electricity sources serve New Mexico loads). If a consumption-based emissions approach is adopted by the State, further analysis should be directed towards the resources that utilities use to meet New Mexico loads, and methods that can be reliably used to track them.

Attachment D-2. Fossil Fuel Industry Emissions[32]

The oil and gas industry has played an instrumental role in New Mexico's economy and livelihoods for more than 70 years. Oil and gas revenues currently provide about 20% New Mexico's General Fund -- down from historic highs of nearly 90% -- and the industry provides employment for about 10,000 New Mexicans.[33] The State currently ranks second in the nation in natural gas production and fifth in crude oil production.[34] It is also a leader in both the production and reserves of carbon dioxide, which is used largely for enhanced oil recovery.

Natural gas production is concentrated in the northwestern corner of the State (San Juan Basin), while oil production occurs predominantly in the southeast (Permian Basin). (See Figure D-12) As of 2002, over 700 oil and gas industry-related companies operated in the State, working 21,771 oil wells, 23,261 gas wells, 456 CO2 wells, 4,097 enhanced recovery injection wells and 597 salt water disposal wells.[35] In response to expectations of strong US natural gas demands and firm prices, it is expected that another nearly 10,000 gas wells may be drilled in the San Juan Basin in coming years.[36] In addition, there are over 4,500 inactive, non-plugged oil and gas wells that could potentially be returned to production.[37]

Figure D-12. Fossil Fuel and CO2 Producing Regions of New Mexico



Source: http://geoinfo.nmt.edu/resources/petroleum/

While coalbed methane (CBM) supplies less than 10% of total US natural gas production, it accounts for nearly a third of New Mexico's natural gas production: 487 of the 1625 billion cubic feet (BCF) produced in 2002.[38] Coalbed methane is found throughout the Rocky Mountain Region, including the Raton and San Juan Basins that span both Colorado and New Mexico. The Fruitland Coal formation of the San Juan Basin is the largest CBM source in the US.

CBM production from the New Mexico portion of the San Juan Basin peaked in 1999 at over 610 Bcf (billion cubic feet), and has since dropped under 500 BCF annually since 2002. At the same time, increased drilling in response to

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[32] The Energy Supply Technical Working Group reviewed and accepted the assumptions and results shown in this section.
[33] EMNRD, 2003. *New Mexico's Natural Resources 2003* http://www.emnrd.state.nm.us/Mining/resrpt/default.htm
[34] US DOE Energy Information Agency website. www.eia.gov
[35] ENMRD, 2003.
[36] Bureau of Land Management, 2003. Farmington Resource Management Plan with Record of Decision, December 2003. Farmington Field Office.
[37] EMNRD, 2003
[38] EMNRD, 2003 and data provided separately by the Oil Conservation Division.

expected high demand and prices for natural gas could postpone further decreases in CBM production. Overall, future oil and gas production levels remain highly uncertain, dependent on prevailing oil and gas prices and the potential development of new reserves.

Oil and Gas Industry Emissions

The sheer number and wide diversity of oil and gas activities in New Mexico present a major challenge for greenhouse gas assessment. Emissions of carbon dioxide and methane occur at many stages of the production process (drilling, production, and processing/refining), and can be highly dependent upon local resource characteristics (pressure, depth, water content, etc.), technologies applied, and practices employed (such as well venting to unload liquids which may result in the release of billions of cubic feet of methane annually). With over 40,000 oil and gas wells in the State, three oil refineries, several gas processing plants, and tens of thousands of miles of gas pipelines in the State – and no regulatory requirements to track CO_2 or CH_4 emissions – there are significant uncertainties with respect to the State's GHG emissions from this sector.

At the same time, considerable research – sponsored by the American Petroleum Institute, the Gas Research Institute, US EPA, and others – has been directed towards developing relatively robust GHG emissions estimates at the national level. For the national GHG inventory, US EPA uses a combination of top-down and detailed bottom-up techniques to estimate national emissions of methane from the oil and gas industry (USEPA, 2005). As noted earlier, US EPA has also developed a tool (SGIT) that enables the development of state-level GHG estimates, whereby emissions-related activity levels (numbers of wells, and amount of oil and gas produced) can be multiplied by aggregate emission factors to yield rough estimates of total CH4 emissions. Furthermore, EIA provides estimates of fuel used in New Mexico for natural gas production, processing, and distribution, which enables the estimation of CO2 emissions.

These sources provide a starting point for analysis of New Mexico's oil and gas industry emissions. Additional data and insights have been solicited from industry sources, including the New Mexico Oil and Gas Association (NMOGA) and individual facility managers, US EPA staff, and State agency experts. These sources provided "ground truthing" on several aspects related to State emissions. For example:

- Oil refiners and NMED provided access to permit data that includes estimated fuel consumption. These sources suggest that refinery gas use is over twice the level suggested by EIA data.
- USEPA staff remarked that methane emissions from well venting activities in New Mexico, especially at low pressure CBM sites where the build up of liquids may require venting, appear to be quite significant, perhaps on the order of 40 BCF annually (1.6 million $MMtCO_2eq$).[39]

[39] Personal communication, Roger Fernandez. (It also appears that that some producers have been able modify practices to reduce well venting emissions by about 50%, suggesting a potentially significant source of emission reductions.) This is only one of several significant sources of methane emissions from gas production. The preferred USEPA (SGIT) approach for estimating natural gas production emissions, which involves multiplying national aggregate per well CH4 emissions by the number of New Mexico wells, yields total methane emissions

- NMOGA provided separate estimates for several emissions sources, including carbon dioxide emissions from gas well site equipment (gas combustion in engines, tank heaters, and field separators), and methane and carbon dioxide emissions from venting and flashing activities at field sites. While these data only cover gas production activities in the San Juan Basin, they suggest rates of field gas use (carbon dioxide) and methane emissions that are 50% to 70% higher than the above (EPA-based) estimates. We consider these rates below in a sensitivity analysis.
- Raw gas that emerges from gas and oil wells often contains "entrained" CO_2 in excess of pipeline specifications. This CO_2 is typically separated at gas processing plants and vented to the atmosphere (except in some other states, such as Wyoming and Texas, where it is compressed and transported for enhanced oil recovery).[40] In the case of New Mexico, the CO_2 concentrations of Fruitland CBM are known to be quite significant (currently around 18%), and these concentrations have been rising over time. Data provided by the Oil Conservation Division of EMNRD and NMOGA enable estimates of entrained CO_2 emissions. Though these estimates cover only Fruitland CBM, which accounts for less that a third of New Mexico gas production, it is thought that this is the most significant source of entrained CO2 in the State.
- CO_2 from enhanced oil recovery – In New Mexico, carbon dioxide is extracted from natural formations (Bravo Dome), piped to oil fields, and injected into wells in order to increase yields. Any release of this CO2 during the extraction, transmission, injection, or oil production processes would lead to net emissions to the atmosphere. At the national level, USEPA currently excludes any such emissions from the national inventory, since they are not well understood. In the case of New Mexico practices, NMED is currently looking into available information to assess where any estimates are possible.

Table D-12 provides an overview of the methods used to estimate and project GHG emissions from the various oil and gas sector activities. As shown, a variety of methods were used, in general relying upon local data and guidance from industry and other experts wherever possible.

Several factors will drive future GHG emissions from New Mexico's oil and gas sector, among them:

- Future oil and gas production activity. This is perhaps the most important, yet most uncertain variable that will affect future GHG emissions. One assessment suggests that barring further discovery or development of new reserves, coalbed methane production will remain level for one or two more years, and then begin declining at rate of 13% annually as the fields are depleted.[41] Conventional gas production in the San Juan Basin, under this assessment, would remain flat through the end of the decade, and similarly

estimates that are significantly less than the national average (per unit natural gas produced), which does not appear justified. Based on discussions with USEPA staff, it was felt that their alternative (SGIT) method – using the New Mexico production-weighted share of national natural gas production methane emissions – would be a better approach for developing initial methane emissions estimates.

[40] On a national level, the USEPA GHG inventory suggests that these entrained CO_2 emissions are quite significant (about 25 MMtCO2in 2002). However, USEPA is still working to systematically incorporate this emissions source into the national inventory, given concerns about double counting emissions in locations (outside New Mexico) where this CO_2 may be used for enhanced oil recovery.

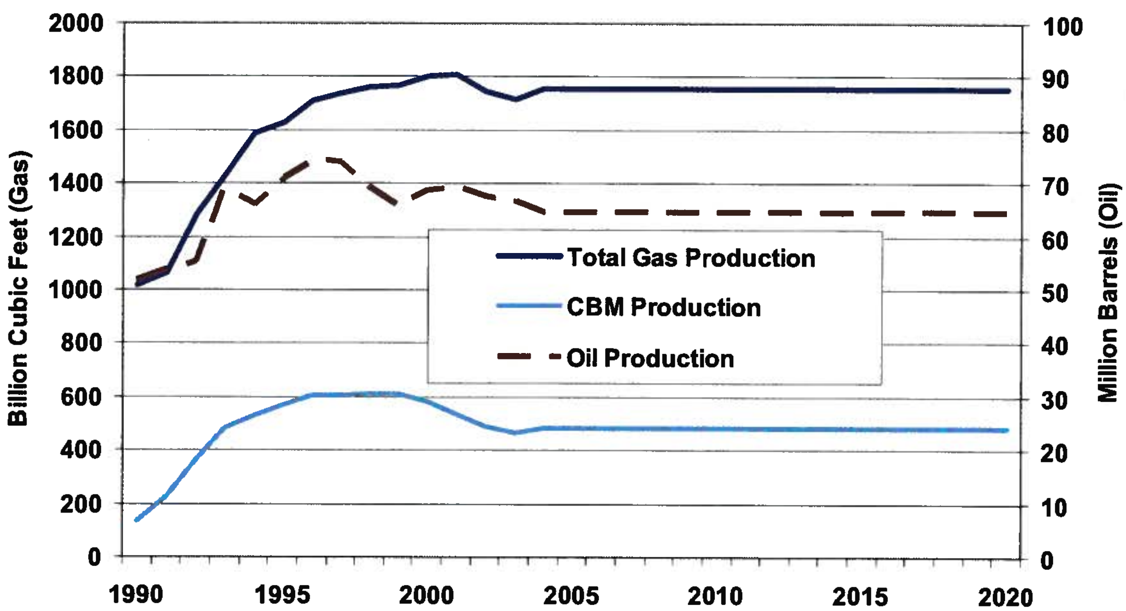
[41] Bernstein Research Call, May 27, 2005.

begin declining at 13% per year. (This assessment covered only the San Juan Basin)

Not surprisingly, there are many competing views on the future of oil and gas production, and prognostications of declining production have been made in the past. Total statewide natural gas production has been relatively steady from 1997 to 2004, varying by less than 6% over this 8-year time period. Thus another possible scenario is that additional reserves are found and exploited such that production remains constant through 2020. The Energy Supply Technical Working Group evaluated the differing views on future oil and gas production and came to the conclusion that the most likely was that emissions remain constant in the sector, and this assumption was used in preparing this inventory.

The implications of this assumption in terms of oil and gas production are depicted in Figure D-13 below.

Figure D-13. Future Oil and Gas Production



- Number of operating wells. As many of the oil and gas fields play out, more operating wells may be needed to maintain production levels. Some emissions, fugitive methane in particular, may depend on the number of operating wells as much as on total oil and gas production. The projected increase in the number of operating wells is based on the estimates contained in the BLM's Resource Management Plan for the San Juan Basin. Note that this estimate will likely need to be adjusted to correspond to the oil and gas production scenario chosen above.

- Changes in production, processing, and pipeline technologies and practices. In response to industry and USEPA emission reduction initiatives (e.g. GasStar), as well as technological advancements, progress has been made in lower GHG emissions per unit of oil and gas produced and delivered. Further improvements are likely, but have not been estimated for this initial analysis.

Key assumptions are noted in Table D-11.

Table D-11. Key Assumptions for the Oil and Gas Sector Projections

Parameter	Assumption
Natural Gas and Oil Production	Flat oil and gas production through 2020 See text for details
Oil Refinery Production	No changes in refinery activities (or emissions) are presently assumed.
GHG emissions per unit input/output	Potential emissions savings particularly for methane could be considerable, but are not considered here due to lack of information.

Coal Production Emissions

Methane occurs naturally in coal seams, and is typically vented during mining operations for safety reasons. This methane is typically referred to as "coal mine methane" in contrast coal bed methane, which is associated with coal seams (such as Fruitland) that are not expected to be mined.

Historical coal mine methane emissions were estimated using the EPA SGIT tool, which multiplies coal production times an average emission factor, depending on the mine type. Coal mine methane emissions are considerably higher, in general, per unit of coal produced, from underground mining than from surface mining.

As of 2003, six surface mines were operation in New Mexico. In 2001, underground operations commenced at the San Juan coal mine, and since then surface operations at one other mine (Ancho) has been significantly curtailed. The increasing share of underground coal in recent years has led to an increase in estimated coal mine methane emissions from about 0.2 MMtCO2e to 0.7 MMtCO2e.

Future coal mine methane emissions will depend on the extent to which operations continue to move underground (which could increase emissions significantly) and/or new coal mining operations change in response to demands from the power market. No effort has yet been made to estimate these potential changes.

Table D-12. Emissions Sources and Estimation Methods for the Oil and Gas Sector

Activity	Emissions Source	Approach to Estimating Historical Emissions	Projection Approach
Natural Gas Drilling and Field Production	CO_2 from field use of natural gas	EIA data	Changes with number of operating wells. (CH_4 emissions savings due to further NG Star activity not considered).
	CH_4 from leaks, venting, upsets, etc.	NM share of national emissions (based on total production). EPA staff separately estimate 40 BCF CH_4 (1.6 MMtCO2e) could result from well venting alone.	
Natural Gas Processing	CO_2 from fuel use in gas processing	EIA data	Changes with total statewide gas production or for the case of entrained CO2, with Fruitland gas production. CO_2 concentrations of Fruitland CBM are assumed to increase based on recent trends.
	CO_2 released fro entrained CO_2	Based on NMOGA estimates of CO2 concentration, and NM Oil Conservation Division estimates of gas production, for the Fruitland CBM field. No estimates made for other gas production sources.	
	CH_4 from leaks, venting, upsets, etc.	NM share of national emissions (based on state vs. US production)	
Natural Gas Transmission and Distribution	CO_2 from fuel use (pumps, compressors)	EIA data	Distribution emissions grow with state gas consumption. No changes currently assumed for transmission-related emissions. Could decrease due to further NG Star activity.
	CH_4 from leaks, venting, upsets, etc.	NM share of transmission & distribution national emissions, based on NM share of national transmission line mileage (transmission) and natural gas consumption (distribution)	
Oil Production	CO_2 from fuel use	EIA data	Grows with state oil production.
	CH_4 from leaks, venting, upsets	SGIT tool.	
Oil Refining	CO_2 from on-site fuel use (refinery gas and natural gas)	Based on fuel use and capacity as reported to NMED in permit data. No annual variations considered.	Grows with oil refinery output.
	CH_4 from leaks and combustion	SGIT tool (included with production above)	
Oil Transport	CO_2 from field use of natural gas	No estimates available	Grows with state oil production.
	CH_4 from combustion	SGIT tool (included with production above)	
Carbon Dioxide Production	CO_2: Fugitive Losses	Not included/no information available.	n/a
	CO_2: Enhanced Oil Recovery	Not yet estimated	n/a
	CO_2: Other uses (shown with industrial process emissions)	Production data. Assume only 1% is for non-oil recovery applications (EMNRD as cited in USEPA, 2005).	No changes assumed.

Overall Results

The resulting emissions estimates for the fossil fuel industry are shown in Table D-13 below. As shown, total fossil fuel industry emissions are quite significant, increasing from 15 to nearly 20 MMtCO2e during the 1990s, largely as the result of increased gas production, and in particular of coalbed methane, which led to an increase in the release of entrained carbon dioxide by over 4 MMtCO2. As shown in this table, GHG emissions would likely remain near 2000 levels through 2020, assuming no new and major efforts to reduce fuel use and/or emissions.

Table D-13. Emissions Estimates for the Oil and Gas Sector, by Source and Gas, 1990-2020 (Scenario A)

(Million Metric Tons CO2e)	1990	2000	2010	2020	Explanatory Notes for Projections
Fossil Fuel Industry	**15.2**	**19.5**	**20.3**	**20.7**	
Natural Gas Industry	**12.7**	**17.0**	**17.3**	**17.7**	
Production					
Fuel Use (CO2)	1.8	2.0	1.9	1.9	grows with gas production
Methane Emissions (CH4)	1.9	3.4	3.7	3.7	grows with gas production
Processing					
Fuel Use (CO2)	1.9	2.1	2.0	2.0	grows with gas production
Methane Emissions (CH4)	0.8	0.8	0.9	0.9	grows with gas production
Entrained Gas (CO2)	0.8	5.0	5.2	5.6	grows with CBM prod & CO2 concentration
Transmission					
Fuel Use (CO2)	4.2	2.3	2.3	2.3	no change assumed from 2003 on
Methane Emissions (CH4)	1.0	0.9	0.9	0.9	no change assumed from 2003 on
Distribution					
Fuel Use (CO2)					included in transmission (above)
Methane Emissions (CH4)	0.4	0.4	0.3	0.4	grows with gas consumption
Oil Industry	**2.3**	**2.3**	**2.3**	**2.3**	
Production					
Fuel Use (CO2)					included in industrial oil use (above)
Methane Emissions (CH4)	0.7	0.7	0.7	0.7	grows with oil production
Refineries					
Fuel Use (CO2)	1.6	1.6	1.6	1.6	assumes no major changes
Methane Emissions (CH4)					included in oil production (above)
Coal Mining (Methane)	**0.2**	**0.2**	**0.7**	**0.7**	no change assumed from 2003 on

These results as noted earlier are highly sensitive to several assumptions, most notably emissions rates associated with natural gas production activities and future trajectories for oil and gas production. If the emissions rates estimated by NMOGA for oil and gas activities in the San Juan Basin (in 2002) are assumed to apply for all gas production activities in the State, then natural gas production emissions would be about 3 to 4 MMtCO2e higher than shown in Table D-13.[42]

[42] Estimated emissions for 2002 (not shown) would be 2.5 MMtCO2e higher for methane, and 0.9 MMtCO2e higher for carbon dioxide.

Major Uncertainties and Other Issues

The uncertainties in emissions for the fossil fuel industry are perhaps more significant than in any sector other than forestry. Methane emissions and entrained carbon dioxide emissions in gas production and processing represent over half of these emissions. However, these emissions are not directly monitored and can only be estimated using industry assumptions. Field practices can vary considerably, e.g. with respect to flashing and venting, depending on the operator and the resource involved, and there is no monitoring of these practices. There are also significant with respect to methane emissions in transmission and distribution systems, since there is no systematic monitoring and emissions from venting and leaks can vary considerably from site to site.

In addition, significant uncertainties remain with respect to:

- The quality of historical data on field, processing, and pipeline use of natural gas.
- CO2 emissions from enhanced oil recovery, which have not been estimated.
- Refinery fuel use. EIA indicates less than half the refinery fuel use as indicated by refinery permit data.
- Coal mine methane. More accurate estimates would require mine-specific measurements.

Description of Sources of Methane emissions in the Oil and Gas Industry

Excerpted from the US national GHG inventory (USEPA, 2005)

Petroleum Systems

- *Production Field Operations*. Production field operations account for over 95 percent of total CH_4 emissions from petroleum systems. Vented CH_4 from field operations account for approximately 83 percent of the emissions from the production sector, fugitive emissions account for six percent, combustion emissions ten percent, and process upset emissions barely one percent. The most dominant sources of vented emissions are field storage tanks, natural gas-powered pneumatic devices (low bleed, high bleed, and chemical injection pumps). These four sources alone emit 79 percent of the production field operations emissions. Emissions from storage tanks occur when the CH_4 entrained in crude oil under pressure volatilizes once the crude oil is put into storage tanks at atmospheric pressure.
- *Crude Oil Transportation.* Crude oil transportation activities account for less than one percent of total CH_4 emissions from the oil industry.
- *Crude Oil Refining*. Crude oil refining processes and systems account for only three percent of total CH_4 emissions from the oil industry because most of the CH_4 in crude oil is removed or escapes before the crude oil is delivered to the refineries.

Natural Gas Systems

- *Field Production*. In this initial stage, wells are used to withdraw raw gas from underground formations. Emissions arise from the wells themselves, gathering pipelines, and well-site gas treatment facilities such as dehydrators and separators. Fugitive emissions and emissions from pneumatic devices account for the majority of emissions. Emissions from field production accounted for approximately 34 percent of CH_4 emissions from natural gas systems in 2003.
- *Processing*. In this stage, natural gas liquids and various other constituents from the raw gas are removed, resulting in "pipeline quality" gas, which is injected into the transmission system. Fugitive emissions from compressors, including compressor seals, are the primary emission source from this stage. Processing plants account for about 12 percent of CH_4 emissions from natural gas systems.
- *Transmission and Storage*. Natural gas transmission involves high pressure, large diameter pipelines that transport gas long distances from field production and processing areas to distribution systems or large volume customers such as power plants or chemical plants. Compressor station facilities, which contain large reciprocating and turbine compressors, are used to move the gas throughout the United States transmission system. Fugitive emissions from these compressor stations and from metering and regulating stations account for the majority of the emissions from this stage. Pneumatic devices and engine exhaust are also sources of emissions from transmission facilities. Natural gas is also injected and stored in underground formations, or liquefied and stored in above ground tanks, during periods of low demand (e.g., summer), and withdrawn, processed, and distributed during periods of high demand (e.g., winter). Compressors and dehydrators are the primary contributors to emissions from these storage facilities. Methane emissions from transmission and storage sector account for approximately 32 percent of emissions from natural gas systems.
- *Distribution*. Distribution pipelines take the high-pressure gas from the transmission system at "city gate" stations, reduce the pressure and distribute the gas through primarily underground mains and service lines to individual end users. Distribution system emissions, which account for approximately 22 percent of emissions from natural gas systems, result mainly from fugitive emissions from gate stations and non-plastic piping (cast iron, steel). An increased use of plastic piping, which has lower emissions than other pipe materials, has reduced the growth in emissions from this stage.

Attachment D-3. Transportation Energy Use

The Transportation and Land Use Technical Working Group reviewed the GHG inventory and forecast, and the corresponding assumptions, for the transportation sector. In particular, this group discussed and reviewed the assumptions regarding gasoline fuel economy and the growth in freight VMT. After this review, the group recommended that the inventory and forecast be accepted with no changes.

The transportation sector is a major source of GHG emissions in New Mexico – large distances, dispersed population and export-based industry lead to high transportation demand and energy consumption (NMDOT 2004)[43]. New Mexico has the largest State road system, measured in lane miles, of all the Rocky Mountain States.[44] Arizona, Utah and Colorado have higher annual vehicle miles traveled (VMT) than New Mexico due to higher populations but New Mexico has a much greater fraction of VMT from freight vehicles (which consume more energy and generate more emissions per mile), much of this for interstate traffic.

By way of comparison, vehicles in New Mexico traveled about 19 billion miles in 2002, compared with 40 billion miles in Colorado. However 19% of the VMT in New Mexico was from freight, compared with 8% in Colorado – indicating similar total freight VMT in each state.[45] According to the *New Mexico 2025 Statewide Multimodal Transportation plan,* "local trucking industry experts predict that commercial truck traffic will double in New Mexico in the next ten years."[46] This report also notes that 85% of commercial traffic on I-10 and I-40 is simply crossing the State, without delivering or picking up any freight.

As shown in Figure D-15, these conditions influence the State's GHG emissions. While gasoline consumption, which accounts for the majority of transportation GHG emissions, increased by 26% from 1990 to 2003 (same rate as the population growth), diesel use increased by 77%.[47] Energy consumption and emissions from air travel increased by only 8% during the 1990s, while natural gas and other fuels (accounting for less than 1% of emissions) decreased during this same time period.

Since 1990/91, Bernalillo County has had oxygenate requirements for their winter gasoline that may be met by mixing ethanol with gasoline. Ethanol consumption is deducted from fuel sales reported by EIA SEDS in order to calculate GHG emissions from gasoline use.[48] (Since ethanol

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[43] NMDOT 2005. *New Mexico 2025 Statewide Multimodal Transportation Plan.* http://www.nmshtd.state.nm.us/upload/images/Long_Range_Planning_Section/GuidingPrinciples/FulfillingNMDOTs_GuidingPrinciples.pdf

[44] 27,346 lane miles, compared with the Rocky Mountain state average of 17,744 lane miles

[45] Data from NMDOT 2004 *Facts and Figures 2004* http://www.nmshtd.state.nm.us/upload/images/pdf/factsandfigures.pdf.

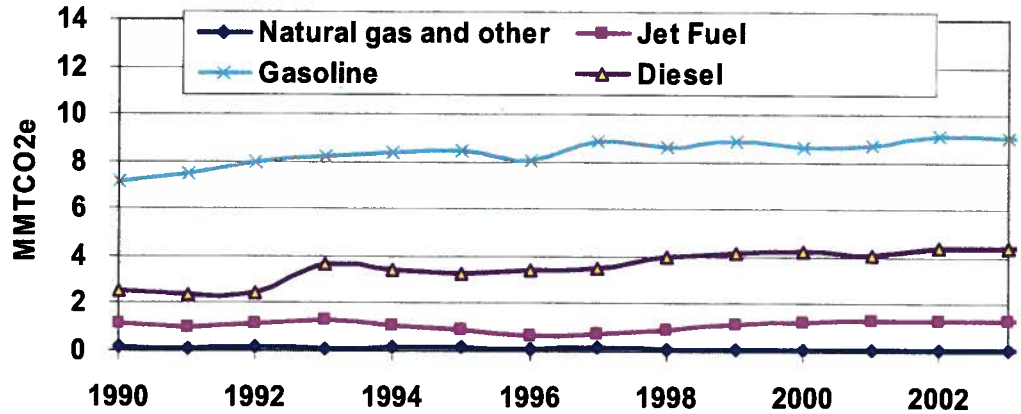
[46] Page 31, NMDOT, 2005.

[47] Data from NMDOT (personal communication, R. Olcott) and EIA SEDS show similar trends in gasoline and diesel consumption.

[48] Based on information regarding the months ethanol is blended (4), and oxygenate requirements (7.7%), ethanol consumption is estimated at 12 million gallons in 1990 and 73 million gallons in 2003.

is a biomass-derived fuel, its CO2 emissions are not typically counted in inventory assessments.[49])

Figure D-14. GHG Emissions by Fuel, 1990-2003



Source: NM DOT for gasoline and diesel and EIA SEDS for all other fuels. Increase in diesel use in 1993 may be an artifact of data collection methods and needs to be double-checked.

GHG emissions from transportation are expected to grow considerably over the next 15 years due to population growth and increased demand on transportation services. New Mexico studies suggest vehicle miles traveled (VMT) will continue to grow faster than population.[50] As a simplifying assumption, it is projected that energy consumption per VMT (i.e. vehicle fuel economy) will remain constant from 2002 to 2020. The assumption of constant energy per VMT is a place-holder until better information is available for New Mexico.[51] Other assumptions are listed in Table D-14.

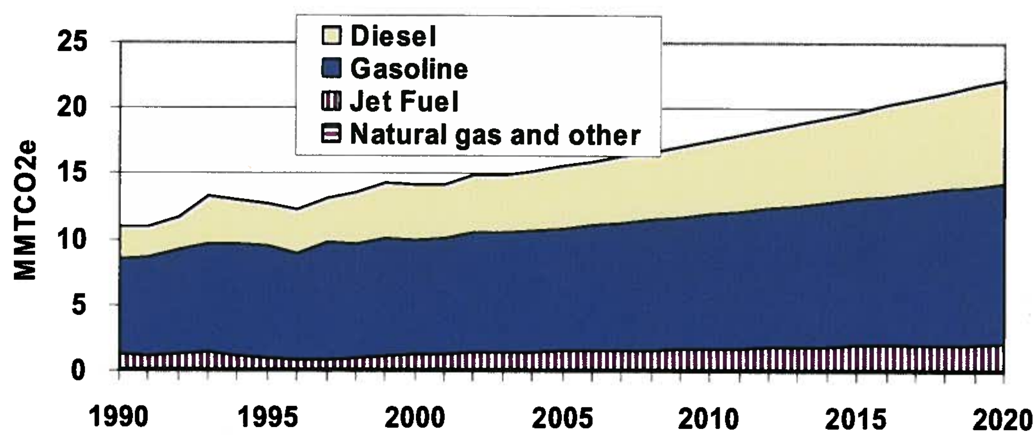
These assumptions combine to produce more than a 50% increase of transportation sector GHG emissions from 2000 to 2020. Diesel consumption shows the greatest increase (80%), due to the assumed growth in VMT. Both jet fuel and gasoline are expected to increase at slightly more than population growth.

[49] Nonetheless, ethanol, like gasoline, can require significant upstream GHG emissions in production and refining.
[50] The *New Mexico 2025 Statewide Multimodal Transportation Plan* is the primary source for VMT growth estimates. This report assumed average annual growth of 1.8% per year (an analysis for the area surrounding and including Bernallilo County assumed VMT growth rate of 1.9% per year (B Ives per com 2005). As reported at the start of the Attachment, the *2025 Statewide Plan* indicates that some experts are projecting freight VMT to double over the next ten years – this implies an annual growth rate of 7.3%. However, that rate was not used in the analysis in the *2025 Statewide Plan*. The projections reported here use a 3.6% growth rate for freight VMT, an intermediate point between the personal VMT projections and the assumed doubling in 10 years. This growth rate is twice the rate of personal VMT growth, but half the rate of that implied by doubling in 10 years. Further analysis is suggested here.
[51] Neither the Mid-County Council County of Government planners nor the NMDOT planners project energy consumption directly. EIA AEO2005 shows this rate declining for both the country and the Rocky Mountain region.

Table D-14. Key Assumptions and Methods for Transportation Projections

Passenger VMT growth	The average annual growth rate for VMT is assumed to be 2% from 2002 to 2020, based on *New Mexico 2025* report.
Gasoline consumption	Gasoline use is assumed to grow with passenger VMT; no change in gasoline use per VMT is assumed.
Ethanol consumption	Average annual ethanol consumption is assumed to remain at 0.7% of total gasoline consumption (representing Bernalillo county winter fuel requirements).
Freight VMT growth	The average annual growth rate for VMT is assumed to be 3.6% from 2002 to 2020.
Diesel consumption	Diesel use is assumed to grow with freight VMT; no change in diesel use per VMT is assumed.
Aviation fuel, jet fuel, natural gas and propane	The average annual growth rates for these fuels are based on EIA AEO2005 growth rates for region (2.5% for aviation gasoline and jet fuel, 0% for natural gas and 5% for propane). Ethanol consumption is projected to grow by 7.8% per year (EIA AEO2005).

Figure D-15. Transportation GHG Emissions, 1990-2020



Key uncertainties

With respect to the historical inventory, uncertainties with respect to transportation fuel use and emissions are relatively low. Fuel use estimates are based on NMDOT data drawn from tax receipts, and USEPA fuel-specific CO2 emission factors are relatively accurate. The principal uncertainties, not surprisingly, relate to projections of future emissions, in particular the projected rate of VMT growth for freight and passenger vehicles. In particular for freight VMT, there are significant differences between what EIA projects for the region and the implications of the ten-year doubling in truck traffic projected by NM DOT. Discussions are underway with staff at the Strategic Planning Bureau of NMDOT and the Mid-County Council of Governments to resolve some of these differences.

Another key uncertainty is projected energy consumption per VMT. Since many of the issues that have high importance for planners (congestion, local air pollution) are only indirectly related to energy consumption, estimates for this information for New Mexico may not be available from local transportation planning offices.

Attachment D-4. Residential, Commercial, and Non-Fossil Fuel Industrial Energy Use[52]

This Attachment reports GHG emissions from fuel consumption in the residential, commercial[53] and non-fossil fuel industrial (RCI) sectors. GHG emissions from non-energy sources (such as cement production) are reported in Attachment D-5, while emissions from the fossil fuel industries are reported in Attachment D-2.[54] The RCI sectors emit carbon dioxide, methane, and nitrous oxide emissions as fuels are combusted for space heating, process heating, and other applications. Carbon dioxide accounts for over 99% of these emissions on a tCO2e basis.

Direct use of coal, oil[55], natural gas, and wood[56] in these sectors resulted in about 7 MMTCO2e of GHG emissions in 2002. Since these sectors consume electricity, one can also attribute emissions from electricity consumption to these sectors.[57] If electricity-related emissions are included, then these sectors account for nearly 28 MMTCO2e in 2002, with electricity use accounting for three-fourths of RCI emissions. If past trends continue – relatively rapid growth in electricity use combined with slower growth in the use of gas, oil, and coal – electricity will increasingly dominate the RCI sectors in New Mexico both in terms of energy use and GHG emissions.

Overall electricity consumption for the three sectors increased by an average of 2.8% per year from 1990 to 2002; electricity-related emissions grew at a slower annual rate of 2.2%, as emissions per kWh declined (see Attachment D-1). Nearly half of direct fuel use occurs within the industrial sector, and this has declined in recent years, mostly likely due to decreased activity in the mining and smelting industries.

Reference case emissions GHG estimates depend upon projections of energy use by sector and source. As described in Attachment D-1, overall, New Mexico electricity use is projected to grow at 2.5% per year, only slightly slower than in the past decade. Lacking detailed projections

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[52] The Residential, Commercial, and Industrial Technical Working Group reviewed the GHG inventory and forecast, and the corresponding assumptions, for these sectors. After this review, the group recommended that the inventory and forecast be accepted with no numerical changes, and suggested the addition of Box 1 shown in Section 1 of the report.

[53] The commercial sector "consists of service-providing facilities and equipment of: businesses; Federal, State, and local governments; and other private and public organizations, such as religious, social, or fraternal groups. The commercial sector includes institutional living quarters. It also includes [energy consumed at] sewage treatment facilities" EIA 2002. *State Energy Data 2001, Technical Notes*, page 5. http://www.eia.doe.gov/emeu/states/sep_use/notes/use_intro.pdf.

[54] Efforts were made to ensure that fuel use by fossil fuel industries reported in Attachment D-2 are not included (i.e. double counted) in this section.

[55] Propane (aka LPG or liquid petroleum gas) use is included in oil consumption.

[56] Emissions from wood combustion include only N2O and CH4. Carbon dioxide emissions from biomass are assumed to be "net zero" consistent with USEPA and IPCC methodologies, and any net loss of carbon stocks due to biomass fuel use should be picked up in the land use and forestry analysis.

[57] One could similarly allocate consumption-basis GHG emissions from gas, oil, and coal production, however this would have a much smaller effect, as upstream emissions are typically only about 5-25% of combustion-related emissions on a tCO2e per BTU basis.

for the State, it is further assumed, for the purposes of this initial analysis, the relative growth rates among individual RCI sectors will follow a pattern similar to recent history, as illustrated in Table D-15.

Growth rates for natural gas consumption are based on projections from Public Service Company of New Mexico (GDS Associates Inc 2005).[58] For the direct use of coal and oil, regional projections from the EIA Annual Energy Outlook 2005 are used, and adjusted for New Mexico's growth rates of population and employment, resulting in the growth rates shown in Table D-16.

Table D-15. Electricity Sales Annual Growth Rates, Historical and Projected

Sector	1990-2002	2002-2020
Residential	3.3%	2.9%
Commercial	3.3%	3.0%
Industrial	1.6%	1.4%
Total	**2.8%**	**2.5%**

Table D-16. Projected Annual Growth in Energy Use, by Sector and Fuel, 2002-2020

	1990-2002	2002-2010	2010-2015	2015-2020
Residential				
natural gas	1.2%	2.2%	2.2%	2.2%
petroleum	6.1%	1.8%	1.6%	1.0%
Commercial				
natural gas	-1.0%	2.4%	2.4%	2.4%
petroleum	0.4%	2.5%	1.2%	0.5%
Industrial				
natural gas	2.4%	0.2%	0.2%	0.2%
petroleum	-1.7%	3.8%	1.4%	1.1%
coal	6.1%	1.2%	-0.6%	-0.7%

Figure D-16, Figure D-17, and Figure D-18 illustrate historical and projected emissions for the residential, commercial, and industrial sectors from 1990 to 2020. Electricity consumption accounts for the largest component of each sector's emissions. Both the residential and commercial sectors show significant growth in emissions from 2002 to 2020, due to assumed strong growth in both electricity and natural gas consumption. In the residential sector energy consumption grows at slightly faster rate than population growth, a reflection of increased affluence and service provision (more appliances, etc.). In the commercial sector, electricity consumption outpaces employment while natural gas consumption increases at about the same rate as employment.

[58] GDS Associates Inc. 2005 *The Maximum Achievable Cost Effective Potential for Natural Gas Energy Efficiency in the service area of PNM.* Final Report for PNM, submitted April 30, 2005.

Industrial sector emissions 1990 to 2002 vary from year to year, reflecting variations in business activity. From 2002 to 2020, the assumed growth rate for industrial sector electricity consumption is about half the employment growth with very low growth for natural gas consumption. For both the commercial and industrial sectors energy consumption and resulting GHG emissions are expected to grow at a slower pace than State economic activity, indicating an overall decrease in GHG intensity.[59]

Figure D-16. Residential Sector GHG Emissions from Energy Use

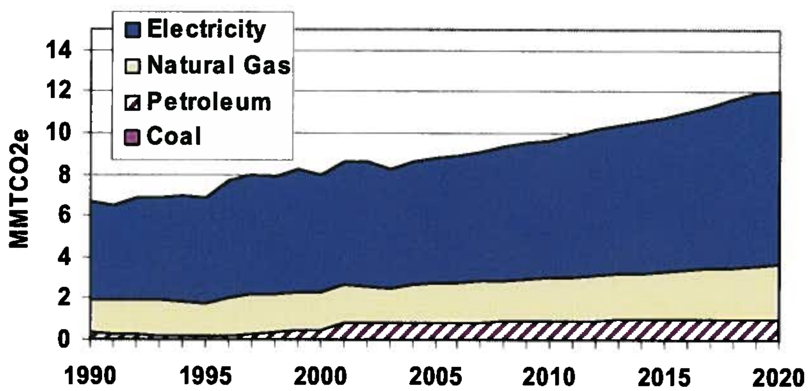
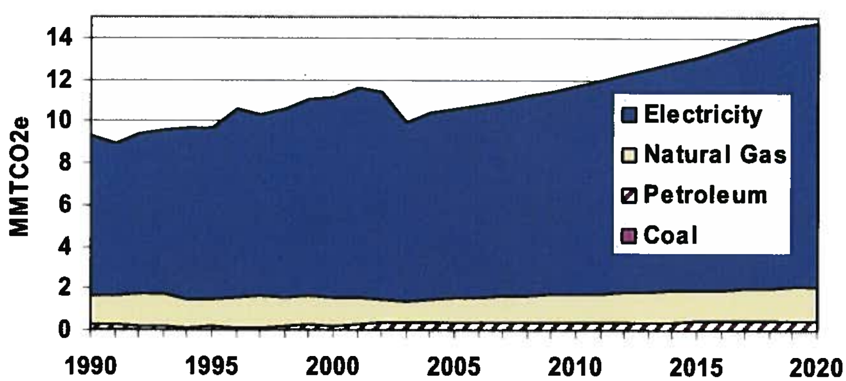


Figure D-17. Commercial Sector GHG Emissions from Energy Use



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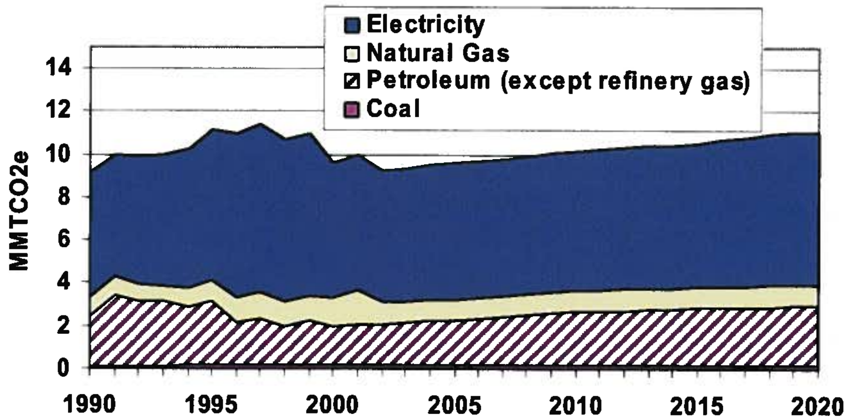
[59] These estimates of growth relative to population and employment reflect expected responses – as modeled by PNM, other electric utilities and the EIA NEMS model -- to changing fuel and electricity prices and technologies, as well as structural changes within each sector (subsectoral shares, energy use patterns, etc.).

Figure D-18. Industrial Sector GHG Emissions from Energy Use



Key Uncertainties

Key sources of uncertainty underlying the inventory and projections are as follows:

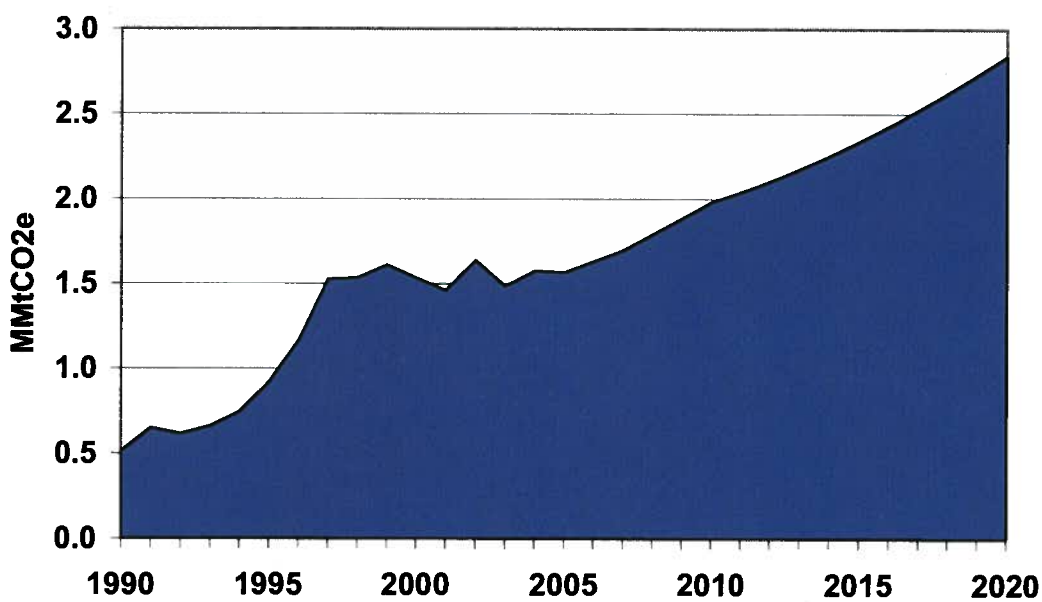
- Population and economic growth are the principal drivers for electricity and fuel use and are subject to significant uncertainties.
- The projections assume no large long-term changes in relative fuel and electricity prices, as compared with current levels and US DOE projections. Should changes would influence consumption levels and encourage switching among fuels.
- It is assumed that energy consumed at military bases and national laboratories are included in the energy statistics from the EIA. However, under-reporting may have occurred but estimating that impact is beyond the scope of this effort.
- Growth of major industries – the energy consumption projections assume no new large energy-consuming facilities and no major changes in mining activity. A few large new facilities – or the decline of major industries – could significantly impact energy consumption and consequent emissions.

Attachment D-5. Industrial Process and Related Emissions[60]

Emissions in this category span a wide range of activities, and reflect non-combustion sources of CO2 from industrial manufacturing (cement, lime, and soda ash production), the release of hydrofluorocarbons (HFCs) from cooling and refrigeration equipment, the use of various fluorinated gases in semiconductor manufacture (perfluorocarbons or PFCs as well as HFCs), and the release of sulfur hexafluoride (SF6) from electricity transformers.

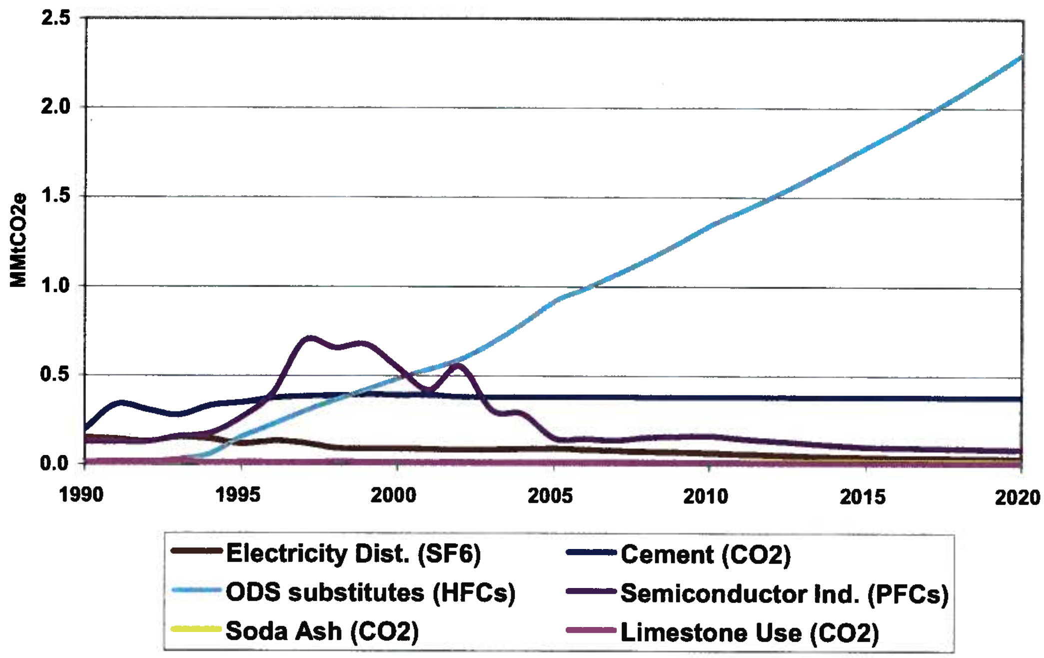
Overall industrial processes and related emissions as shown in Figure D-19, more than tripled from 1990 to 2000 and are expected to continue to grow through 2020. The contributions of each sub-category are shown in Figure D-20 and explained below.

Figure D-19. GHG Emissions from Industrial Processes, 1990-2020



[60] The assumptions and results shown in this section were reviewed and accepted by the Residential, Commercial, and Industrial Technical Working Group.

Figure D-20. GHG Emissions from Industrial Processes, 1990-2020, by Source



From 1990 to 2005 the semi-conductor industry was one of the largest contributors of GHG emissions from industrial processes. These emissions peaked in 1997 but have decreased significantly since then – largely due to voluntary actions by the industry. Intel, the largest manufacturer in New Mexico, provided estimates of its PFC emissions from 1995 to 2004, along with projections to 2010; no estimates were obtained for other manufacturers. Emissions beyond 2010 could increase due to increases in semi-conductor manufacturing, or decrease due to process change and/or continued industry efforts to reduce emissions. Projections from the US Climate Action Report[61] shows expected decreases in PFC emissions at the national level due to a variety of industry actions to reduce emissions, and the rate of decline from that report was applied for emissions from 2010 to 2020.[62]

After 2005, emissions from HFCs in refrigeration and air conditioning equipment dominate the category and show strong growth through 2020. HFCs are being used to substitute for ozone-depleting substances (ODS), most notably CFCs (also potent warming gases) in compliance with the *Montreal Protocol*.[63] Even low amounts of HFC emissions, from leaks and other releases

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61 U.S. Department of State, *U.S. Climate Action Report 2002*, Washington, D.C., May 2002. http://yosemite.epa.gov/oar/globalwarming.nsf/UniqueKeyLookup/SHSU5BNQ76/$File/ch5.pdf

62 Similarly, the Intel data was extrapolated back to 1990, based on 1995 data from Intel and annual change in the national emissions from the US inventory (US EPA 2005 *Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2003*)

63 ODS substitutes are primarily associated with refrigeration and air conditioning, but also many other uses such as fire extinguishers, solvent cleaning, aerosols, foam production ns for ODS substitutes depend on technology characteristics in a range of equipment. For the US national inventory, a detailed stock vintaging model was used, but such analysis has not been completed at the state level. This report uses the EPA SGIT procedure of estimating state-level emissions based on the state's fraction of US population and the US emissions. Growth rates are based on

under normal use of the products, can lead to high GHG emissions. Emissions from the ODS substitutes in New Mexico are estimated to have increased from 0.002 MMTCO2e in 1990 to 0.5 MMTCO2e in 2000, with further increases of 8% per year expected from 2000 to 2020. The estimates for the emissions in New Mexico are based on the State's population and estimates of emissions per capita from the US EPA national GHG inventory.[64]

Emissions of SF6 from electrical equipment have experienced declines since the early-nineties (see Figure D-20), mostly due to voluntary action by industry. Emissions for New Mexico from 1990 to 2003 were estimated based on the estimates of emissions per kWh from the US EPA GHG inventory (US EPA 2005 *Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2003*) and New Mexico's electricity consumption. The US Climate Action Report[65] shows expected decreases in these emissions at the national level, and the same rate of decline is assumed for emissions in New Mexico The decline in emissions in the future reflects expectations of future actions by the electric industry to reduce these emissions.

Cement production emits CO2 during the calcination process, whereby calcium carbonate (CaCO3) is converted to calcium oxide (CaO). This process also requires significant energy consumption; emissions related to fuel use at cement plants are reported in the RCI section above. The process emissions are directly related to the amount of clinker and masonry cement produced. New Mexico has one cement plant, GCC Rio Grande. For 1990-2002, GHG emissions are calculated as the production from this plant by a standard emission factor of 0.507 tons CO2/ton clinker.[66] Although cement consumption in New Mexico is likely to increase with increased population, much of the cement is supplied from a plant in Mexico. Therefore, pending further analysis and review, no changes in in-state cement production are assumed after 2002.

Emissions from lime manufacture, which also emits CO2 from chemical conversion, have not yet been estimated. Like cement, New Mexico has one lime plant. Production data for this plant are confidential. Thus to develop a rough initial estimate, emissions from limestone use (as well as soda ash) production are based on reported in-state consumption data from the United States Geological Survey (USGS). These rough estimates, suggest emissions from these two sources

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growth in projected national emissions from recent EPA report, US EPA 2004, *Analysis of Costs to Abate International ODS Substitute Emissions,* EPA 430-R-04-006. http://yosemite.epa.gov/oar/globalwarming.nsf/UniqueKeyLookup/RAMR62AS98/$File/IMAC%20Appendices%206-24.pdf

65 U.S. Department of State, *U.S. Climate Action Report 2002*, Washington, D.C., May 2002.
http://yosemite.epa.gov/oar/globalwarming.nsf/UniqueKeyLookup/SHSU5BNQ76/$File/ch5.pdf

66 Annual production from the cement plant was not available so values were estimated as follows. The *New Mexico Greenhouse Gas Action Plan* (WERC 2002) provided estimates of cement production from this plant in 1997 and the United States Geological Survey (USGS) *Cement Annual* lists cement production data for Arizona and New Mexico combined together (for confidentiality reasons). As a first approximation, the fraction of New Mexico production to total Arizona and New Mexico production was calculated for 1997. This same fraction was applied to the USGS value for 1990-2002 to estimate New Mexico cement production.

accounted for less than 4% of industrial process emissions in 1990 and have not grown significantly since. The assumed trend is for these emissions to remain at 2002 levels through 2020.

Key Uncertainties

Since emissions from industrial processes are determined by the level of production and the production processes of a few key industries, there are is relatively high uncertainty regarding future emissions, as they depend on the competitiveness of New Mexico manufacturers, the specific nature of their production processes.

The projected largest source of future industrial emissions, HFCs used in cooling applications, is subject to a number of uncertainties as well. First, historical emissions are based on national estimates; New Mexico-specific estimates are currently unavailable. Second, emissions will be driven by future choices regarding air conditioning technologies and coolants used, for which a number of options currently exist.

Attachment D-6. Agriculture, Forestry and Other Land Use[67]

The emissions discussed in this Attachment refer to non-energy emissions from agriculture, forestry and other land uses. These emissions include emissions from livestock, agriculture soil management and field burning, CO2 emitted and removed (sinks) due to forestry activities and land use change, and emissions linked to rangeland and forest fires.

Figure D-21. GHG emissions from Agriculture, Forestry and Other Land-Use (MMTCO2e)

Reference Case GHG Emissions for New Mexico

(Million Metric Tons CO2e)	1990	2000	2010	2020	Explanatory Notes for Projections
Agriculture, Land Use, and Forestry	**-16.4**	**-15.0**	**-14.5**	**-14.2**	
Agriculture (CH4 & N20)	4.5	6.0	6.4	6.7	Assumes dairy production grows at same rate as population and no growth in other areas after 2004
*Forestry and Land Use	-20.9	-20.9	-20.9	-20.9	Carbon sequestration rates are assumed to remain constant.

Agriculture

Agriculture plays a large role in New Mexico's economy, contributing about $2 billion in annual crop and livestock sales. In 2002, dairy products accounted for $744 million in sales – this industry has grown strongly in the last decade, from ranking 30th state in the country in dairy production in 1990 to 7th in 2002. Cattle sales accounted for $593 million while crops (including feed for stock) made up another $575 million.[68]

GHG emissions from livestock, agriculture soil management and field burning were about 6.2 MMTCO2e in 2004. These emissions include CH4 and N2O emissions from enteric fermentation, manure management, agriculture soils and agriculture residue burning. Data on crops and animals in the State from 1990 to 2004 were obtained from the USDA National Agriculture Statistical Service.[69] As shown in Figure D-22, emissions from these sources increased by about 37% from 1990 to 2004. Emissions from agricultural soils accounted for the largest fraction (about 50%) of agricultural emissions in 1990. Soil-related emissions of N2O occur as the result of activities that increase nitrogen in the soil, including fertilizer (synthetic, organic and livestock) application and the production of nitrogen-fixing crops. These activities remained relatively stable from 1990 to 2004 and consequently emissions increased by only 3% between these years.

[67] The Agriculture and Forestry Technical Working Group reviewed and accepted the assumptions and results shown in this section.
[68] *Agricultural Facts 2002* http://nmdaweb.nmsu.edu/DIVISIONS/AGSTATS/2002/2002%20Ag%20Facts.pdf and *Dairy Facts 2002*, http://nmdaweb.nmsu.edu/DIVISIONS/AGSTATS/2002/2002%20Dairy%20Facts.pdf
[69] Personal communication from NM office of National Agricultural Statistics Service to NMENV May 2005 indicated that the NASS website had the best data on agriculture stocks, data are collected in state and compiled for the NASS site.

Enteric fermentation and manure management accounted for about 42% and 8% of agriculture emissions in 1990, respectively. Enteric fermentation is another term for the microbial process of breaking down food in digestive systems, which results in methane emissions that are especially large among ruminants, such as cattle and sheep. Largely as the result of the expansion of dairy farming in New Mexico, enteric fermentation emissions increased by 24% from 1990 to 2004 – and now appear to exceed GHG emissions from agricultural soils.

Of the agricultural emissions sources, manure management emissions have risen the most rapidly– almost tripling from 1990 to 2004. This large increase reflects the growth in the dairy industry – the number of dairy cows in New Mexico increased from about 90 thousand head in 1990 to almost 400 thousand head in 2004 (in contrast the number of beef cattle declined by about 10%).[70] Emissions from agriculture residue burning are very small and decreased by 26% from 1990 to 2002.

As a first approximation for projecting emissions from this source, the growth rate for dairy cattle is assumed to match the State population growth rate, 1.2% per year. This rate is lower than the growth from 1995 to 2004 of 6.5%, and reflects constraints to continued rapid growth, such as expected higher costs for future water rights and gasoline, along with increased productivity per animal. For other animal stock, a simple assumption of no change from 2004 levels was applied. It is also assumed that emission rates per animal (based on animal weight, feed and management strategies for stock and land) remain at the 2004 levels.

As illustrated in Figure D-22, total GHG emissions from agriculture increased by 32% from 1990 to 2000, and are projected to increase another 13% by 2020.

Forestlands

Forest land emissions refer to the net CO2 flux[71] from forested lands in New Mexico, which account for about 27% of the State's land area. These net forest and land use sequestration estimates are based on recent improvements to US Forest Service carbon stock inventory from earlier estimates published in 1997 by Birdsey and Lewis.[72] Updated results include a more accurate definition of the year in which data was actually collected (some 1987 data was earlier reported as 1982), and updated tree biomass and soil carbon calculations based on new field studies.

[70] While beef cattle significantly outnumber dairy cows in New Mexico, the number of dairy cows has grown rapidly. While total cattle grew by 11% during this period, enteric fermentation emissions increased by 24% and manure management by 310%. Per animal enteric fermentation emissions are somewhat higher for dairy cows and manure management emissions are substantially higher, due to anaerobic conditions created by manure collection systems at dairy farms. Note that these figures do not consider a reported 6,000 animal population of domesticated bison, whose enteric fermentation emissions probably exceed beef cows. Also, to the extent dairy operations are using dry waste-management (feedlot) systems, SGIT may overestimate manure management emissions. Methane and nitrous oxide emissions from agricultural residue burning were calculated using default values in SGIT. More specific information on the amount of residue burned in New Mexico might be available in the future from NMED's Smoke Management Program, which requires tracking and reporting of such burning.

[71] "Flux" refers to both emissions of CO2 to the atmosphere and removal (sinks) of CO2 from the atmosphere.

[72] Thomas D. Peterson, James E. Smith and Jack D. Kartez (2005). Development of Forestry Related Climate Change Mitigation Options for the State of Maine. The Journal of Environmental Quality (available in prepublication format).

Figure D-22. GHG Emissions from Agriculture

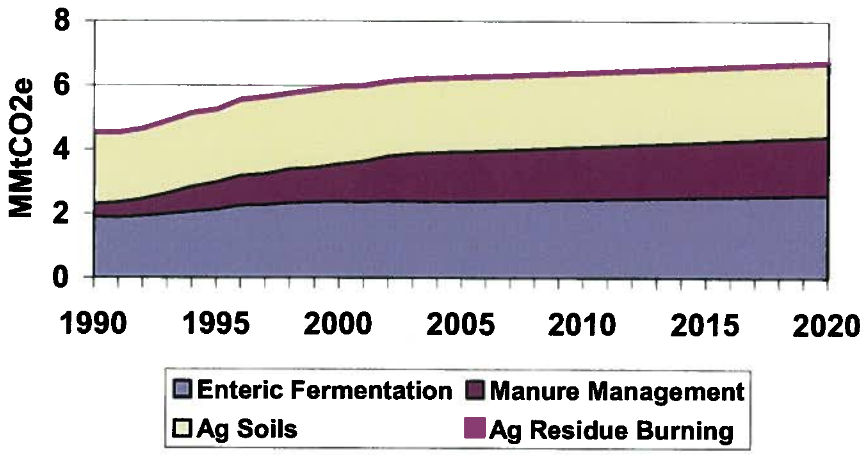

Table D-17. GHG Emissions (Sinks) from Forestry and Other Activities

	1990	2000
Live and dead-standing trees and understory	-13.6	-13.6
Forest floor and coarse woody debris	-3.1	-3.1
Soils	-5.9	-5.9
Wood products and landfills	1.8	1.8
Total	**-20.9**	**-20.9**

Additional land cover change, wood products, and import/export estimates from secondary sources could change current results. The Technical Workgroup did not identify any changes that could be made within the time and resource constraints for this project. According to the US Forest Service there are no methods available to correct for changes in the definition of forestland that occurred during the FIA survey period. During the FIA survey periods used for carbon stock estimates, the definition of forestland changed from a minimum forest cover requirement of 10% to a minimum of 5%. As a result, differences occur in the number of forested acres simply as a result in the change of input data. Also, rangelands may or may not be included in these estimates of forested area, depending on their level of tree stocking. Finally, Data is not available from FIA for years 1997-2002 due to lack of state funding for USDA Forest Service inventory of lands in New Mexico.

Uncertainties and Further Analysis

US Forest Service assessments only cover the parts of the State that the US Forest Service defines as forest, representing 27% of the total State land area in 1997. To the extent that they may sequester or emit carbon, while small on a per acre basis, rangelands may be quite significant at the State level.[73] While modeling methods exist to quantify inter-annual carbon pools for rangelands (and hence the level of carbon flux), time and resource constraints did not allow for the Technical Workgroup to develop estimates for rangelands. It is recommended that future analyses explore carbon flux for rangelands.

Due to funding constraints in New Mexico, US Forest Service data from the FIA are not available for the 1997-2002 period. As a result, biomass reductions from wildfires and forest health problems, or other carbon stock changes during this period, are not reflected in the averages reported for the previous decade. The current forecasts for forest carbon projections are based solely a linear extrapolation of the 1987-1997 period for which data are available. Future research should explore the impacts on carbon sequestration of projected forest health, forest products usage, and other forestry management programs.

[73] However, the carbon cycle for rangelands is not well understood, and has not been included in current surveys.

Attachment D-7. Waste Management

GHG emissions from waste management are summarized in Table D-18. Emissions in this category include:

- Solid waste management – methane emissions from landfills, accounting for any methane that is flared or captured for energy production, and
- Wastewater management – methane and nitrous oxide from municipal wastewater treatment facilities.

Any emissions associated with energy consumed to transport of solid waste and wastewater are included in the RCI accounting above.

Table D-18. Emissions from Waste Management

Reference Case GHG Emissions for New Mexico

(Million Metric Tons CO2e)	1990	2000	2010	2020	Explanatory Notes for Projections
Waste Management	**0.8**	**1.2**	**1.4**	**1.2**	
Solid Waste Management	0.6	1.0	1.1	0.9	Based on national projections (US DptState)
Wastewater Management	0.2	0.2	0.3	0.3	Increases with state population

The EPA SGIT tool was used to estimate solid waste management emissions from 1990 to 2003.[74] However, since emissions from these types of facilities are site-specific, we are also working with NMED to determine if better estimates exist. The information in the EPA SGIT tool was updated with data from NMED on waste generated and imported into the State from 1993 to 2003. Further discussion are underway with the NMED and landfill operators to check the emissions avoided by flaring at Camino Real, Cerro Colorado, Los Angeles landfill in Albuquerque and other landfills.

For emissions from 2004 to 2020, growth rates are based on national projections by the US Department of State.[75] These projections decrease over time, accounting for improved methane recovery practices. Conversations with NMED indicate that 5-6 new landfill gas recovery systems are likely to be added to New Mexico landfills over the next 5 years, supporting the assumptions of decreased landfill emissions even accounting for increased solid waste generation as population grows.

Emissions from wastewater were also estimated using the EPA SGIT tool. These emissions increased by 1.9% per year from 1990 to 2003.[76] Projected emissions are assumed to increase with population growth, 1.2% per year from 2004 to 2020.

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[74] EPA SGIT uses amount of waste in place at landfills, characteristics of landfill (size, moisture levels), amount of landfill gas recovered and flared and oxidation levels to estimate state emissions from landfills.
[75] US Department of State (2002). *US Climate Action Report 2002*. Washington DC May 2002.
[76] Emissions are calculated in EPA SGIT based on state population, assumed biochemical oxygen demand and protein consumption per capita, and emission factors for N2O and CH4.

Attachment D-8. List of Contacts

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Sam Speaker, NMED, (electric plant permits)
John O'Connell, NMED, (solid waste bureau)
Lawrence Alires, NMED, (air quality bureau)

Craig O'Hare, Energy, Minerals and Natural Resources Department (EMNRD), Energy Conservation and Management Division
Chris Wentz, EMNRD, Energy Conservation and Management Division
Dan Hagan, EMNRD, Energy Conservation and Management Division

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Roy Cornelius, NMDOT (long range plan)
Elizer Pena, NMDOT (historic VMT)
Becky Valencia, NMDOT (historic VMT)
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Berry Ives, Mid-Region Council of Governments of NM (long term plan for Bernalillo county)

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Roger Fernandez, US Environmental Protection Agency (USEPA) (Natural Gas Star)
Lisa Hanle, USEPA (US Inventory, Oil and Gas)

Leif Hocksted, USEPA (US Inventory)
Andrea Denny, USEPA (SGIT tool)
Pamela Franklin, US EPA (Coal Mine Methane)

Perry Lindstrom, US DOE, Energy Information Administration

Joel Farrell, US Bureau of Land Management

Jim Smith, US Forest Service

James Russell, Environ Corporation

Attachment D-9. Greenhouse Gases and Global Warming Potential Values

Excerpts from the *Inventory of U.S. Greenhouse Emissions and Sinks: 1990-2000*

Original Reference: All material taken from the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 - 2000*, U.S. Environmental Protection Agency, Office of Atmospheric Programs, EPA 430-R-02-003, April 2002. www.epa.gov/globalwarming/publications/emissions

Introduction

The *Inventory of U.S. Greenhouse Gas Emissions and Sinks* presents estimates by the United States government of U.S. anthropogenic greenhouse gas emissions and removals for the years 1990 through 2000. The estimates are presented on both a full molecular mass basis and on a Global Warming Potential (GWP) weighted basis in order to show the relative contribution of each gas to global average radiative forcing.

The Intergovernmental Panel on Climate Change (IPCC) has recently updated the specific global warming potentials for most greenhouse gases in their Third Assessment Report (TAR, IPCC 2001). Although the GWPs have been updated, estimates of emissions presented in the U.S. *Inventory* continue to use the GWPs from the Second Assessment Report (SAR). The guidelines under which the *Inventory* is developed, the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC/UNEP/OECD/IEA 1997) and the United Nations Framework Convention on Climate Change (UNFCCC) reporting guidelines for national inventories[77] were developed prior to the publication of the TAR. Therefore, to comply with international reporting standards under the UNFCCC, official emission estimates are reported by the United States using SAR GWP values. This excerpt of the U.S. *Inventory* addresses in detail the differences between emission estimates using these two sets of GWPs. Overall, these revisions to GWP values do not have a significant effect on U.S. emission trends.

Additional discussion on emission trends for the United States can be found in the complete Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2000.

What is Climate Change?

Climate change refers to long-term fluctuations in temperature, precipitation, wind, and other elements of the Earth's climate system. Natural processes such as solar-irradiance variations, variations in the Earth's orbital parameters, and volcanic activity can produce variations in climate. The climate system can also be influenced by changes in the concentration of various gases in the atmosphere, which affect the Earth's absorption of radiation.

The Earth naturally absorbs and reflects incoming solar radiation and emits longer wavelength terrestrial (thermal) radiation back into space. On average, the absorbed solar radiation is balanced by the outgoing terrestrial radiation emitted to space. A portion of this terrestrial radiation, though, is itself absorbed by gases in the atmosphere. The energy from this absorbed terrestrial radiation warms the Earth's surface and atmosphere, creating what is known as the "natural greenhouse effect." Without the natural heat-trapping properties of these atmospheric gases, the average surface temperature of the Earth would be about 33°C lower (IPCC 2001).

Under the UNFCCC, the definition of climate change is "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods." Given that definition, in its Second Assessment Report of the science of climate change, the IPCC concluded that:

[77] See FCCC/CP/1999/7 at <www.unfccc.de>.

Human activities are changing the atmospheric concentrations and distributions of greenhouse gases and aerosols. These changes can produce a radiative forcing by changing either the reflection or absorption of solar radiation, or the emission and absorption of terrestrial radiation (IPCC 1996).

Building on that conclusion, the more recent IPCC Third Assessment Report asserts that "[c]oncentrations of atmospheric greenhouse gases and their radiative forcing have continued to increase as a result of human activities" (IPCC 2001).

The IPCC went on to report that the global average surface temperature of the Earth has increased by between 0.6 ± 0.2°C over the 20th century (IPCC 2001). This value is about 0.15°C larger than that estimated by the Second Assessment Report, which reported for the period up to 1994, "owing to the relatively high temperatures of the additional years (1995 to 2000) and improved methods of processing the data" (IPCC 2001).

While the Second Assessment Report concluded, "the balance of evidence suggests that there is a discernible human influence on global climate," the Third Assessment Report states the influence of human activities on climate in even starker terms. It concludes that, "[I]n light of new evidence and taking into account the remaining uncertainties, most of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations" (IPCC 2001).

Greenhouse Gases

Although the Earth's atmosphere consists mainly of oxygen and nitrogen, neither plays a significant role in enhancing the greenhouse effect because both are essentially transparent to terrestrial radiation. The greenhouse effect is primarily a function of the concentration of water vapor, carbon dioxide, and other trace gases in the atmosphere that absorb the terrestrial radiation leaving the surface of the Earth (IPCC 1996). Changes in the atmospheric concentrations of these greenhouse gases can alter the balance of energy transfers between the atmosphere, space, land, and the oceans. A gauge of these changes is called radiative forcing, which is a simple measure of changes in the energy available to the Earth-atmosphere system (IPCC 1996). Holding everything else constant, increases in greenhouse gas concentrations in the atmosphere will produce positive radiative forcing (i.e., a net increase in the absorption of energy by the Earth).

Climate change can be driven by changes in the atmospheric concentrations of a number of radiatively active gases and aerosols. We have clear evidence that human activities have affected concentrations, distributions and life cycles of these gases (IPCC 1996).

Naturally occurring greenhouse gases include water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and ozone (O_3). Several classes of halogenated substances that contain fluorine, chlorine, or bromine are also greenhouse gases, but they are, for the most part, solely a product of industrial activities. Chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) are halocarbons that contain chlorine, while halocarbons that contain bromine are referred to as bromofluorocarbons (i.e., halons). Because CFCs, HCFCs, and halons are stratospheric ozone depleting substances, they are covered under the Montreal Protocol on Substances that Deplete the Ozone Layer. The UNFCCC defers to this earlier international treaty; consequently these gases are not included in national greenhouse gas inventories. Some other fluorine containing halogenated substances—hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6)—do not deplete stratospheric ozone but are potent greenhouse gases. These latter substances are addressed by the UNFCCC and accounted for in national greenhouse gas inventories.

There are also several gases that, although they do not have a commonly agreed upon direct radiative forcing effect, do influence the global radiation budget. These tropospheric gases—referred to as ambient air pollutants—include carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and tropospheric (ground level) ozone (O_3). Tropospheric ozone is formed by two precursor pollutants, volatile organic compounds (VOCs) and nitrogen oxides (NO_x) in the presence of ultraviolet light (sunlight). Aerosols—extremely small particles or liquid droplets—often composed of sulfur compounds, carbonaceous combustion products, crustal materials and other human induced pollutants—can affect the absorptive characteristics of the atmosphere. However, the level of scientific understanding of aerosols is still very low (IPCC 2001).

Carbon dioxide, methane, and nitrous oxide are continuously emitted to and removed from the atmosphere by natural processes on Earth. Anthropogenic activities, however, can cause additional quantities of these and other greenhouse gases to be emitted or sequestered, thereby changing their global average atmospheric concentrations. Natural activities such as respiration by plants or animals and seasonal cycles of plant growth and decay are examples of processes that only cycle carbon or nitrogen between the atmosphere and organic biomass. Such processes—except when directly or indirectly perturbed out of equilibrium by anthropogenic activities—generally do not alter average atmospheric greenhouse gas concentrations over decadal timeframes. Climatic changes resulting from anthropogenic activities, however, could have positive or negative feedback effects on these natural systems. Atmospheric concentrations of these gases, along with their rates of growth and atmospheric lifetimes, are presented in Table 1.

Table 1: Global atmospheric concentration (ppm unless otherwise specified), rate of concentration change (ppb/year) and atmospheric lifetime (years) of selected greenhouse gases

Atmospheric Variable	CO_2	CH_4	N_2O	SF_6 [a]	CF_4 [a]
Pre-industrial atmospheric concentration	278	0.700	0.270	0	40
Atmospheric concentration (1998)	365	1.745	0.314	4.2	80
Rate of concentration change [b]	1.5 [c]	0.007 [c]	0.0008	0.24	1.0
Atmospheric Lifetime	50-200 [d]	12 [e]	114 [e]	3,200	>50,000

Source: IPCC (2001)

[a] Concentrations in parts per trillion (ppt) and rate of concentration change in ppt/year.

[b] Rate is calculated over the period 1990 to 1999.

[c] Rate has fluctuated between 0.9 and 2.8 ppm per year for CO_2 and between 0 and 0.013 ppm per year for CH4 over the period 1990 to 1999.

[d] No single lifetime can be defined for CO_2 because of the different rates of uptake by different removal processes.

[e] This lifetime has been defined as an "adjustment time" that takes into account the indirect effect of the gas on its own residence time.

A brief description of each greenhouse gas, its sources, and its role in the atmosphere is given below. The following section then explains the concept of Global Warming Potentials (GWPs), which are assigned to individual gases as a measure of their relative average global radiative forcing effect.

Water Vapor (H_2O). Overall, the most abundant and dominant greenhouse gas in the atmosphere is water vapor. Water vapor is neither long-lived nor well mixed in the atmosphere, varying spatially from 0 to 2 percent (IPCC 1996). In addition, atmospheric water can exist in several physical states including gaseous, liquid, and solid. Human activities are not believed to directly affect the average global concentration of water vapor; however, the radiative forcing produced by the increased concentrations of other greenhouse gases may indirectly affect the hydrologic cycle. A warmer atmosphere has an increased water holding capacity; yet, increased concentrations of water vapor affects the formation of clouds, which can both absorb and reflect solar and terrestrial radiation. Aircraft contrails, which consist of water vapor and other aircraft emittants, are similar to clouds in their radiative forcing effects (IPCC 1999).

Carbon Dioxide (CO_2). In nature, carbon is cycled between various atmospheric, oceanic, land biotic, marine biotic, and mineral reservoirs. The largest fluxes occur between the atmosphere and terrestrial biota, and between the atmosphere and surface water of the oceans. In the atmosphere, carbon predominantly exists in its oxidized form as CO_2. Atmospheric carbon dioxide is part of this global carbon cycle, and therefore its fate is a complex function of geochemical and biological processes. Carbon dioxide concentrations in the atmosphere increased from approximately 280 parts per million by volume (ppmv) in pre-industrial times to 367 ppmv in 1999, a 31 percent increase (IPCC 2001). The IPCC notes that "[t]his concentration has not been exceeded during the past 420,000 years, and likely not during the past 20 million years. The rate of increase over the past century is unprecedented, at least during the past 20,000 years." The IPCC definitively states that "the present atmospheric CO_2 increase is caused by anthropogenic emissions of CO_2" (IPCC 2001). Forest clearing, other biomass burning, and some non-energy production processes (e.g., cement production) also emit notable quantities of carbon dioxide.

In its second assessment, the IPCC also stated that "[t]he increased amount of carbon dioxide [in the atmosphere] is leading to climate change and will produce, on average, a global warming of the Earth's surface because of its enhanced greenhouse effect—although the magnitude and significance of the effects are not fully resolved" (IPCC 1996).

Methane (CH_4). Methane is primarily produced through anaerobic decomposition of organic matter in biological systems. Agricultural processes such as wetland rice cultivation, enteric fermentation in animals, and the decomposition of animal wastes emit CH_4, as does the decomposition of municipal solid wastes. Methane is also emitted during the production and distribution of natural gas and petroleum, and is released as a by-product of coal mining and incomplete fossil fuel combustion. Atmospheric concentrations of methane have increased by about 150 percent since pre-industrial times, although the rate of increase has been declining. The IPCC has estimated that slightly more than half of the current CH_4 flux to the atmosphere is anthropogenic, from human activities such as agriculture, fossil fuel use and waste disposal (IPCC 2001).

Methane is removed from the atmosphere by reacting with the hydroxyl radical (OH) and is ultimately converted to CO_2. Minor removal processes also include reaction with Cl in the marine boundary layer, a soil sink, and stratospheric reactions. Increasing emissions of methane reduce the concentration of OH, a feedback which may increase methane's atmospheric lifetime (IPCC 2001).

Nitrous Oxide (N_2O). Anthropogenic sources of N_2O emissions include agricultural soils, especially the use of synthetic and manure fertilizers; fossil fuel combustion, especially from mobile combustion; adipic (nylon) and nitric acid production; wastewater treatment and waste combustion; and biomass burning. The atmospheric concentration of nitrous oxide (N_2O) has increased by 16 percent since 1750, from a pre industrial value of about 270 ppb to 314 ppb in 1998, a concentration that has not been exceeded during the last thousand years. Nitrous oxide is primarily removed from the atmosphere by the photolytic action of sunlight in the stratosphere.

Ozone (O_3). Ozone is present in both the upper stratosphere, where it shields the Earth from harmful levels of ultraviolet radiation, and at lower concentrations in the troposphere, where it is the main component of anthropogenic photochemical "smog." During the last two decades, emissions of anthropogenic chlorine and bromine-containing halocarbons, such as chlorofluorocarbons (CFCs), have depleted stratospheric ozone concentrations. This loss of ozone in the stratosphere has resulted in negative radiative forcing, representing an indirect effect of anthropogenic emissions of chlorine and bromine compounds (IPCC 1996). The depletion of stratospheric ozone and its radiative forcing was expected to reach a maximum in about 2000 before starting to recover, with detection of such recovery not expected to occur much before 2010 (IPCC 2001).

The past increase in tropospheric ozone, which is also a greenhouse gas, is estimated to provide the third largest increase in direct radiative forcing since the pre-industrial era, behind CO_2 and CH_4. Tropospheric ozone is produced from complex chemical reactions of volatile organic compounds mixing with nitrogen oxides (NO_x) in the presence of sunlight. Ozone, carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2) and particulate matter are included in the category referred to as "criteria pollutants" in the United States under the Clean Air Act and its subsequent amendments. The tropospheric concentrations of ozone and these other pollutants are short-lived and, therefore, spatially variable.

Halocarbons, Perfluorocarbons, and Sulfur Hexafluoride (SF_6). Halocarbons are, for the most part, man-made chemicals that have both direct and indirect radiative forcing effects. Halocarbons that contain chlorine—chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), methyl chloroform, and carbon tetrachloride—and bromine—halons, methyl bromide, and hydrobromofluorocarbons (HBFCs)—result in stratospheric ozone depletion and are therefore controlled under the Montreal Protocol on Substances that Deplete the Ozone Layer. Although CFCs and HCFCs include potent global warming gases, their net radiative forcing effect on the atmosphere is reduced because they cause stratospheric ozone depletion, which is itself an important greenhouse gas in addition to shielding the Earth from harmful levels of ultraviolet radiation. Under the Montreal Protocol, the United States phased out the production and importation of halons by 1994 and of CFCs by 1996. Under the Copenhagen Amendments to the Protocol, a cap was placed on the production and importation of HCFCs by non-Article 5 countries beginning in 1996, and then followed by a complete phase-out by the year 2030. The ozone depleting gases covered under the Montreal Protocol and its Amendments are not covered by the UNFCCC.

Hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6) are not ozone depleting substances, and therefore are not covered under the Montreal Protocol. They are, however, powerful greenhouse gases. HFCs—primarily used as replacements for ozone depleting substances but also emitted as a by-product of the HCFC-22 manufacturing process—currently have a small aggregate radiative forcing impact; however, it is anticipated that their contribution to overall radiative forcing will increase (IPCC 2001). PFCs and SF_6 are predominantly emitted from various industrial processes including aluminum smelting, semiconductor manufacturing, electric power transmission and distribution, and magnesium casting. Currently, the radiative forcing impact of PFCs and SF_6 is also small; however, they have a significant growth rate, extremely long atmospheric lifetimes, and are strong absorbers of infrared radiation, and therefore have the potential to influence climate far into the future (IPCC 2001).

Carbon Monoxide (CO). Carbon monoxide has an indirect radiative forcing effect by elevating concentrations of CH_4 and tropospheric ozone through chemical reactions with other atmospheric constituents (e.g., the hydroxyl radical, OH) that would otherwise assist in destroying CH_4 and tropospheric ozone. Carbon monoxide is created when carbon-containing fuels are burned incompletely. Through natural processes in the atmosphere, it is eventually oxidized to CO_2. Carbon monoxide concentrations are both short-lived in the atmosphere and spatially variable.

Nitrogen Oxides (NO_x). The primary climate change effects of nitrogen oxides (i.e., NO and NO_2) are indirect and result from their role in promoting the formation of ozone in the troposphere and, to a lesser degree, lower stratosphere, where it has positive radiative forcing effects. Additionally, NO_x emissions from aircraft are also likely to decrease methane concentrations, thus having a negative radiative forcing effect (IPCC 1999). Nitrogen oxides are created from lightning, soil microbial activity, biomass burning – both natural and anthropogenic fires – fuel combustion, and, in the stratosphere, from the photo-degradation of nitrous oxide (N_2O). Concentrations of NO_x are both relatively short-lived in the atmosphere and spatially variable.

Nonmethane Volatile Organic Compounds (NMVOCs). Nonmethane volatile organic compounds include compounds such as propane, butane, and ethane. These compounds participate, along with NO_x, in the formation of tropospheric ozone and other photochemical oxidants. NMVOCs are emitted primarily from transportation and industrial processes, as well as biomass burning and non-industrial consumption of organic solvents. Concentrations of NMVOCs tend to be both short-lived in the atmosphere and spatially variable.

Aerosols. Aerosols are extremely small particles or liquid droplets found in the atmosphere. They can be produced by natural events such as dust storms and volcanic activity, or by anthropogenic processes such as fuel combustion and biomass burning. They affect radiative forcing in both direct and indirect ways: directly by scattering and absorbing solar and thermal infrared radiation; and indirectly by increasing droplet counts that modify the formation, precipitation efficiency, and radiative properties of clouds. Aerosols are removed from the atmosphere relatively rapidly by precipitation. Because aerosols generally have short atmospheric lifetimes, and have concentrations and compositions that vary regionally, spatially, and temporally, their contributions to radiative forcing are difficult to quantify (IPCC 2001).

The indirect radiative forcing from aerosols are typically divided into two effects. The first effect involves decreased droplet size and increased droplet concentration resulting from an increase in airborne aerosols. The second effect involves an increase in the water content and lifetime of clouds due to the effect of reduced droplet size on precipitation efficiency (IPCC 2001). Recent research has placed a greater focus on the second indirect radiative forcing effect of aerosols.

Various categories of aerosols exist, including naturally produced aerosols such as soil dust, sea salt, biogenic aerosols, sulphates, and volcanic aerosols, and anthropogenically manufactured aerosols such as industrial dust and carbonaceous aerosols (e.g., black carbon, organic carbon) from transportation, coal combustion, cement manufacturing, waste incineration, and biomass burning.

The net effect of aerosols is believed to produce a negative radiative forcing effect (i.e., net cooling effect on the climate), although because they are short-lived in the atmosphere—lasting days to weeks—their concentrations respond rapidly to changes in emissions. Locally, the negative radiative forcing effects of aerosols can offset the positive forcing of greenhouse gases (IPCC 1996). "However, the aerosol effects do not cancel the global-scale effects of the much longer-lived greenhouse gases, and significant climate changes can still result" (IPCC 1996).

The IPCC's Third Assessment Report notes that "the indirect radiative effect of aerosols is now understood to also encompass effects on ice and mixed-phase clouds, but the magnitude of any such indirect effect is not known, although it is likely to be positive" (IPCC 2001). Additionally, current research suggests that another constituent of aerosols, elemental carbon, may have a positive radiative forcing (Jacobson 2001). The primary anthropogenic emission sources of elemental carbon include diesel exhaust, coal combustion, and biomass burning.

Global Warming Potentials

Global Warming Potentials (GWPs) are intended as a quantified measure of the globally averaged relative radiative forcing impacts of a particular greenhouse gas. It is defined as the cumulative radiative forcing—both direct and indirect effects—integrated over a period of time from the emission of a unit mass of gas relative to some reference gas (IPCC 1996). Carbon dioxide (CO_2) was chosen as this reference gas. Direct effects occur when the gas itself is a greenhouse gas. Indirect radiative forcing occurs when chemical transformations involving the original gas produce a gas or gases that are greenhouse gases, or when a gas influences other radiatively important processes such as the atmospheric lifetimes of other gases. The relationship between gigagrams (Gg) of a gas and Tg CO_2 Eq. can be expressed as follows:

$$\text{Tg } CO_2 \text{ Eq} = (\text{Gg of gas}) \times (\text{GWP}) \times \left(\frac{\text{Tg}}{1{,}000 \text{ Gg}} \right)$$

where,

Tg CO_2 Eq. = Teragrams of Carbon Dioxide Equivalents
Gg = Gigagrams (equivalent to a thousand metric tons)
GWP = Global Warming Potential
Tg = Teragrams

GWP values allow policy makers to compare the impacts of emissions and reductions of different gases. According to the IPCC, GWPs typically have an uncertainty of roughly ±35 percent, though some GWPs have larger uncertainty than others, especially those in which lifetimes have not yet been ascertained. In the following decision, the parties to the UNFCCC have agreed to use consistent GWPs from the IPCC Second Assessment Report (SAR), based upon a 100 year time horizon, although other time horizon values are available (see Table 2).

> *In addition to communicating emissions in units of mass, Parties may choose also to use global warming potentials (GWPs) to reflect their inventories and projections in carbon dioxide-equivalent terms, using information provided by the Intergovernmental Panel on Climate Change (IPCC) in its Second Assessment Report. Any use of GWPs should be based on the effects of the greenhouse gases over a 100-year time horizon. In addition, Parties may also use other time horizons. (FCCC/CP/1996/15/Add.1)*

Greenhouse gases with relatively long atmospheric lifetimes (e.g., CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6) tend to be evenly distributed throughout the atmosphere, and consequently global average concentrations can be determined. The short-lived gases such as water vapor, carbon monoxide, tropospheric ozone, other ambient air pollutants (e.g., NO_x, and NMVOCs), and tropospheric aerosols (e.g., SO_2 products and black carbon), however, vary spatially, and consequently it is difficult to quantify their global radiative forcing impacts. GWP values are generally not attributed to these gases that are short-lived and spatially inhomogeneous in the atmosphere.

Table 2: Global Warming Potentials (GWP) and Atmospheric Lifetimes (Years) Used in the Inventory

Gas	Atmospheric Lifetime	100-year GWP[a]	20-year GWP	500-year GWP
Carbon dioxide (CO_2)	50-200	1	1	1
Methane (CH_4)[b]	12±3	21	56	6.5
Nitrous oxide (N_2O)	120	310	280	170
HFC-23	264	11,700	9,100	9,800
HFC-125	32.6	2,800	4,600	920
HFC-134a	14.6	1,300	3,400	420
HFC-143a	48.3	3,800	5,000	1,400
HFC-152a	1.5	140	460	42
HFC-227ea	36.5	2,900	4,300	950
HFC-236fa	209	6,300	5,100	4,700
HFC-4310mee	17.1	1,300	3,000	400
CF_4	50,000	6,500	4,400	10,000
C_2F_6	10,000	9,200	6,200	14,000
C_4F_{10}	2,600	7,000	4,800	10,100
C_6F_{14}	3,200	7,400	5,000	10,700
SF_6	3,200	23,900	16,300	34,900

Source: IPCC (1996)
[a] GWPs used here are calculated over 100 year time horizon
[b] The methane GWP includes the direct effects and those indirect effects due to the production of tropospheric ozone and stratospheric water vapor. The indirect effect due to the production of CO_2 is not included.

Table 3 presents direct and net (i.e., direct and indirect) GWPs for ozone-depleting substances (ODSs). Ozone-depleting substances directly absorb infrared radiation and contribute to positive radiative forcing; however, their effect as ozone-depleters also leads to a negative radiative forcing because ozone itself is a potent greenhouse gas. There is considerable uncertainty regarding this indirect effect; therefore, a range of net GWPs is provided for ozone depleting substances.

Table 3: Net 100-year Global Warming Potentials for Select Ozone Depleting Substances*

Gas	Direct	Net_{min}	Net_{max}
CFC-11	4,600	(600)	3,600
CFC-12	10,600	7,300	9,900
CFC-113	6,000	2,200	5,200
HCFC-22	1,700	1,400	1,700
HCFC-123	120	20	100
HCFC-124	620	480	590
HCFC-141b	700	(5)	570
HCFC-142b	2,400	1,900	2,300
$CHCl_3$	140	(560)	0
CCl_4	1,800	(3,900)	660
CH_3Br	5	(2,600)	(500)
Halon-1211	1,300	(24,000)	(3,600)
Halon-1301	6,900	(76,000)	(9,300)

Source: IPCC (2001)

* Because these compounds have been shown to deplete stratospheric ozone, they are typically referred to as ozone depleting substances (ODSs). However, they are also potent greenhouse gases. Recognizing the harmful effects of these compounds on the ozone layer, in 1987 many governments signed the *Montreal Protocol on Substances that Deplete the Ozone Layer* to limit the production and importation of a number of CFCs and other halogenated compounds. The United States furthered its commitment to phase-out ODSs by signing and ratifying the Copenhagen Amendments to the *Montreal Protocol* in 1992. Under these amendments, the United States committed to ending the production and importation of halons by 1994, and CFCs by 1996. The IPCC Guidelines and the UNFCCC do not include reporting instructions for estimating emissions of ODSs because their use is being phased-out under the *Montreal Protocol*. The effects of these compounds on radiative forcing are not addressed here.

The IPCC recently published its Third Assessment Report (TAR), providing the most current and comprehensive scientific assessment of climate change (IPCC 2001). Within that report, the GWPs of several gases were revised relative to the IPCC's Second Assessment Report (SAR) (IPCC 1996), and new GWPs have been calculated for an expanded set of gases. Since the SAR, the IPCC has applied an improved calculation of CO_2 radiative forcing and an improved CO_2 response function (presented in WMO 1999). The GWPs are drawn from WMO (1999) and the SAR, with updates for those cases where new laboratory or radiative transfer results have been published. Additionally, the atmospheric lifetimes of some gases have been recalculated. Because the revised radiative forcing of CO_2 is about 12 percent lower than that in the SAR, the GWPs of the other gases relative to CO_2 tend to be larger, taking into account revisions in lifetimes. However, there were some instances in which other variables, such as the radiative efficiency or the chemical lifetime, were altered that resulted in further increases or decreases in particular GWP values. In addition, the values for radiative forcing and lifetimes have been calculated for a variety of halocarbons, which were not presented in the SAR. The changes are described in the TAR as follows:

New categories of gases include fluorinated organic molecules, many of which are ethers that are proposed as halocarbon substitutes. Some of the GWPs have larger uncertainties than that of others, particularly for those gases where detailed laboratory data on lifetimes are not yet available. The direct GWPs have been calculated relative to CO_2 using an improved calculation of the CO_2 radiative forcing, the SAR response function for a CO_2 pulse, and new values for the radiative forcing and lifetimes for a number of halocarbons.

Table 4 compares the lifetimes and GWPs for the SAR and TAR. As can be seen in Table 4, GWPs changed anywhere from a decrease of 15 percent to an increase of 49 percent.

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Inventory of New Mexico Greenhouse Gas Emissions: 2000 - 2007

Prepared by the New Mexico Environment Department

March 15, 2010

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List of Acronyms and Key Terms

Ag	Agricultural
BACT	Best Available Control Technology
BBER	Bureau of Business and Economic Research
CaO	Calcium Oxide
$CaCO_3$	Calcium Carbonate
CAA	Clean Air Act
CAMD	Clean Air Markets Division
CARB	California Air Resources Board
CCAG	Climate Change Advisory Group
CBM	Coal Bed Methane
CCR	California Code of Regulations
CCS	Center for Climate Strategies
CEMS	Continuous Emissions Monitoring
CH_4	Methane
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide equivalence
EPA EGRID	Environmental Protection Agency Emissions & Generation Resource Integrated Database
EE	Energy Efficiency
EI	Emissions Inventory
EIA	Energy Information Administration
EIIP	Emissions Inventory Improvement Project
EO	Executive Order
EPA	US Environmental Protection Agency
FF	Fossil Fuel

GHG	Greenhouse Gases
GTE	Gas to Energy
GWP	Global Warming Potential
HFCs	Hydrofluorocarbons
LFGTE	Landfill Gas to Energy
MCF	Methane Conversion Factors
$MMTCO_2$	Million Metric Tonnes Carbon Dioxide
$MMTCO_2e$	Million Metric Tonnes Carbon Dioxide Equivalent
$MTCO_2e$	Metric Tonnes Carbon Dioxide Equivalent
MPG	Miles per Gallon
MSW	Municipal Solid Waste
MW	Megawatt
N	Nitrogen
NASS	National Agricultural Statistics Service
NM	New Mexico
NMDOT	New Mexico Department of Transportation
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
NMOG	Non-methane Organic Gas
N_2O	Nitrous Oxide
NOx	Nitrogen Oxides
O_2	Oxygen
O&G	Oil and Gas Sector
ODS	Ozone Depleting Substances
PFCs	Perfluorocarbons
PRC	Public Regulation Commission
RCI	Residential Commercial Industrial
REC	Renewable Energy Certificate
RPS	Renewable Portfolio Standard
SB	Senate Bill
SCR	Selective Catalytic Reduction
SEDS	State Energy Data System
SIT	State Inventory Tool
SF_6	Sulfur Hexafluoride
TCR	The Climate Registry
TEPPCO	Texas Eastern Products Pipeline Company
TWG	Technical Work Group
US	United States
USDA	United States Department of Agriculture
US EPA	United States Environmental Protection Agency
USGS	United State Geological Survey
WCI	Western Climate Initiative
WRAP	Western Regional Air Partnership

Executive Summary

This document, Inventory of New Mexico Greenhouse Gas (GHG) Emissions: 2000-2007 (hereafter referred to as 2007 Update), is a statewide compilation and analysis of GHG emissions data. The 2007 Update has been compiled as mandated in Governor Bill Richardson's Executive Orders (2005-033 & 2006-69) to provide an update regarding trends of greenhouse gas emissions in the state. This report will be updated on a quadrennial basis to evaluate statewide GHG emissions on a sector basis, providing information for decision makers to gain a broad perspective about the relative contribution of each sector as it relates to the State's GHG portfolio. The data, analysis and trends derived from this report will help inform future climate change policy.

Governor Richardson's Administration is at the forefront of states that are addressing climate change. The Governor convened a Climate Change Advisory Group (CCAG) in 2005 that made 69 recommendations to address climate change. The development of a statewide emissions inventory every four years is required by Executive Order 2006-69.[1] The impact that climate change has on the state's economy, environment and public welfare is paramount. Data collected from GHG emitting sectors and their relative contribution to New Mexico's total GHG emissions is important for future policy making. The data, analysis and comparison to the CCAG Report (hereafter referred to as the CCAG Report) facilitate this understanding.

This report discusses GHG emissions, significant issues, trends, and uncertainties from each of the following primary sectors of GHG emissions:

- Fossil fuel combustion
- Fossil fuel industry
- Electricity production
- Transportation
- Residential, commercial and industrial energy consumption
- Industrial processes
- Agriculture
- Waste management

As an initial step to identify trends and to evaluate the last four years of data, the report authors reviewed the methodologies used in the 2004 inventory developed for the CCAG under contract by the Center for Climate Strategies (CCS). However, for some sectors it was difficult if not impossible to mirror the original report methodology because of the proprietary nature of the tools used by the contractor. This 2007 Update relies heavily on the United States Environmental Protection Agency (US EPA or EPA) State Inventory Tool (SIT) and input data from the Energy Information Administration (EIA). The use of these data will ensure that future updates to the State Inventory are compiled with similar methods so that trend analyses and comparisons are meaningful. For purposes of

[1] For information regarding New Mexico's Climate Change efforts and links to the Governor's Executive Orders, see http://www.nmenv.state.nm.us/cc/

comparison, the CCAG emissions estimates for 1990 and 2000 are provided in Table 2 alongside updated estimates for 2000 and 2007. Since the release of the CCAG Report, EPA has made several changes to the SIT, and EIA data are routinely revised. This trend will continue as EPA and states refine emissions data and calculation methodologies.

Although the focus of this report is to provide a top-down inventory, bottom-up data are included. Top-down data (e.g. statewide fuel consumption) are used to estimate emissions from a broad cross section of GHG emitting sources, whereas bottom-up data are estimated from specific emitting unit(s) (e.g., a facility with an air permit). The year 2008 marked the first year for which NMED received GHG reporting data from the largest sources of air pollutants that it regulates (e.g., sources that are subject to the Title V air permitting program[2]). A list of NMED regulated Title V sources emitting 10,000 metric tons or greater CO_2 from combustion and a pie chart highlighting relative contributions of the electric, oil and gas and industrial sectors are found in Section 9 of this report. The development of more robust mandatory reporting required by state and federal rules will facilitate enhanced understanding of the GHG emitting sectors where data can be gathered by source operators.

New Mexico's total GHG emissions are dominated by electricity production and consumption, fossil fuel industry and transportation sectors. Emissions from the residential, commercial and (non-fossil fuel production) industrial sectors are also proportionally significant, with an increase in the use of Ozone Depleting Substitutes (ODS) and relatively steady production in the semi-conductor industry. The Industrial, Agriculture and Waste Management sectors are relatively small contributors to total GHG emissions.

<u>Summary of New Mexico GHG Emissions Trends 2000 – 2007</u>

- After a 3% annual GHG emissions growth rate experienced from 1990 to 2000, the total (gross) direct emissions in New Mexico remained essentially level from 2000 to 2007. The variation in the updated emissions estimates for 2000 and 2008 (about a 1% total decrease over that period) is well with in the margin of error associated with the data (see Table 2). Emissions remained level despite a 6.7%[3] growth in New Mexico's population over that period.
- The largest sources of GHG emissions in 2007 were electricity production (41%), the fossil fuel industry (22%) and transportation fuel use (20%).
- 2007 per capita emissions on a consumption basis were 35 $MtCO_2e$ per person.
- Fossil fuel industry (production, processing and transportation of natural gas, oil and coal) 2007 emissions were 16.9 $MMTCO_2e$, a decrease of 13% from emissions year 2000.
- Approximately 90% of electricity production emissions are from coal-fired power plants.

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[2] A Title V source has the potential to emit 100 or more tons per year of any criteria pollutant, or 10 tons per year of any one hazardous air pollutant, or 25 or more tons of combined hazardous air pollutants listed in Section 112b of the Clean Air Act.

[3] From the US Census Bureau's annual population estimates from 4/1/00 to 7/1/07 (NST-EST2007), released 12/27/07

- $MTCO_2e$/MW-hr production decreased by 7.5% from 2000 to 2007 reflecting increases in electricity production from lower emitting renewable and natural gas electric generating sources.
- GHG emissions from the transportation sector increased 12% reflecting increased freight traffic and increased state population.
- Both the waste management and agricultural sectors showed small total increases in GHG emissions (0.6 and 0.4 $MMtCO_2e$), respectively).
- The total emissions from energy consumption in the commercial sector fluctuated, ending with 2007 emissions at 2000 levels.
- The use of ODS substitutes is now the leading source of GHG emissions from the industrial sector.

1 Inventory of New Mexico Greenhouse Gas Emissions, 2000-2007

1.1 Introduction

This report presents estimates of historical New Mexico anthropogenic GHG emissions for the period from 2000 to 2007. This information has been compiled to support and inform efforts to address anthropogenic climate change, including those of the Climate Change Action Implementation Team, which was created by Executive Order 2006-69 – *New Mexico Climate Change Action*[4]. In some cases, estimates of emissions from 1990 to 2000 have also been included for purposes of evaluating longer term trends. Emissions by sector are reported in Sections 2 through 8. Key findings and summaries of trends are reported in Sections 1.2 to 1.5. The emissions estimation approaches and variations from methods used in the CCAG Report are discussed in Section 1.6.

This analysis updates the historical data available in the report *New Mexico Greenhouse Gas Inventory and Reference Case Projections, 1990-2020*, released by the New Mexico Climate Change Advisory Group (CCAG) in November 2006[5]. That report included historical GHG emissions data through 2003 and projections of emissions for 2004 through 2020. Executive Order 2006-69 directed the New Mexico Environment Department (hereafter referred to as the Department) to update the statewide greenhouse gas emissions estimate every four years. This report includes four additional years of now historical information. Historical data required to estimate emissions for the year 2008 was not available when this report was written.

This report covers the six gases included in the Kyoto Protocol: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). Emissions of these greenhouse gases are presented using a common metric, CO_2 equivalence (CO_2e), which indicates the relative contribution of each gas to global average radiative forcing by weighting them using the Global Warming Potential (GWP) established for each gas. The CCAG Report included an extensive discussion of global warming potentials in Attachment D-9 of that report. Table 1 lists the GWP used in this report.

[4] See link at http://www.nmenv.state.nm.us/cc/

[5] See link at http://www.nmenv.state.nm.us/cc/

Table 1 Global Warming Potentials Used in this Report

Gas	GWP
Carbon dioxide (CO_2)	1
Methane (CH_4)	21
Nitrous oxide (N_2O)	310
HFC-23	11,700
HFC-125	2,800
HFC-134a	1,300
HFC-143a	3,800
HFC-152a	140
HFC-227ea	2,900
HFC-236fa	6,300
HFC-4310mee	1,300
CF_4	6,500
C_2F_6	9,200
C_4F_{10}	7,000
C_6F_{14}	7,400
SF_6	23,900

Source: IPCC (1996)

Unlike the CCAG Report, this estimate does not include emissions sinks. The only sink considered in the CCAG Report was net sequestration by forested lands, and the key source of data for this estimate was a Forest Inventory Analysis survey conducted by the USDA Forest Service. The most recent survey conducted was in 1997, and therefore the available data does not reflect the impact of major fires and forest dieback in more recent years. NMED therefore concluded that simply repeating the earlier value from the CCAG Report would be misleading.

Also unlike the 2006 report, this estimate does not include emissions projections. Projections are developed based on a range of assumptions, which assume that past trends can predict future activities. In some cases these predictions are met. However, current uncertainties regarding the federal GHG program and instability of fuel prices and the economy do not allow the Department to develop valid projections regarding future GHG emissions.

This report and the CCAG report are among several that include emissions estimates related to New Mexico sources. Other reports include:

- The Draft Albuquerque City-wide and Bernalillo County Greenhouse Gas Emissions Inventory (2009 Update)[6].
- The US Environmental Protection Agency's annual Inventory of US Greenhouse Gas Emissions and Sinks[7].

In addition to GHG emissions inventories developed by local, state and federal agencies to estimate regional emissions, a growing number of companies are developing GHG emissions inventories either voluntarily[8] or to meet regulatory reporting requirements. In

[6] http://www.cabq.gov/airquality/
[7] http://www.epa.gov/climatechange/emissions/index.html#inv
[8] Voluntary reporting may be accomplished under a number of programs. The most comprehensive is The Climate Registry (http://www.theclimateregistry.org/).

New Mexico (exclusive of Indian Lands and Bernalillo County), larger emissions sources have reported 2008 CO_2 combustion emissions to the New Mexico Environment Department. A summary of these emissions reports is included here as Section 9. Reports of 2009 CO_2 and methane emissions will be submitted in 2010. The US EPA has recently promulgated a mandatory GHG reporting rule that applies to emissions beginning with emissions year 2010, to be reported in 2011.

1.2 Summary of Key Findings and Trends

As with the CCAG report, this report utilizes several approaches to evaluate emissions of greenhouse gases in New Mexico. As discussed in Sections 1.3 to 1.5, emissions can be evaluated on a production basis, consumption basis or per capita basis. Each approach can offer insights regarding emissions patterns and trends in the state. In addition, sector-specific information may be found in Sections 2 through 8.

In summary, for the period 2000-2007:

- The largest sources of GHG emissions in 2007 were electricity production (41%), the fossil fuel industry (22%) and transportation fuel use (20%). This ranking is consistent with emissions estimations for the years 1990 and 2000.
- After a 3% annual GHG emissions growth rate experienced from 1990 to 2000, the total (gross) direct emissions in New Mexico remained essentially level from 2000 to 2007. The variation in the updated emissions estimates for 2000 and 2008 (about a 1% total decrease over that period) is well with in the margin of error associated with the data (see Table 2). Emissions remained level despite a 6.7% growth in New Mexico's population over that period.
- Consistent with the CCAG Report, this report estimates the per capita emissions for the state on a consumption basis (see Section 1.4). For 2007, the per capita emissions for New Mexico were 35 $MtCO_2e$ per person (see Section 1.5).
- Estimations for emissions from the fossil fuel industry (production, processing and transportation of natural gas, oil, and coal) showed a slight decrease from 2000 (19.1 $MMTCO_2e$) to 2007 (16.9 $MMTCO_2e$). However, significant uncertainty exists regarding emissions estimates for this sector due to inadequate data. In addition, the 2007 estimate may also reflect changes in estimation methodology and data sources for some subsectors. Emissions estimates for this sector are described in Section 2. One trend noted is a five-fold increase in methane emissions from coal mining, which now comprise about 6.5% of the estimated emissions from the fossil fuel industry sector.
- Emissions from electricity generation are due predominantly to coal-fired power plants, which contribute approximately 90% of the total GHG emissions for this sector (see Section 3). However, the emissions per megawatt-hour of electricity produced have decreased by almost 7.5% since 2000, due to increases in the use of natural gas, wind and solar energy to produce electricity.
- GHG emissions from the transportation sector increased 12% (see Section 4). This increase was due to a combination of factors, including increased freight traffic and increased state population. Emissions from diesel fuel use increased by 28% during this period, and the estimated emissions from gasoline consumption increased by 4%.

- While the state population grew 6.7% from 2000-2007 (see Sections 1.4 and 1.5), New Mexicans reduced their average (per capita) emissions from gasoline use by 2.5% and increased their consumption of energy in heating, cooling and power residential buildings by 6%. Over time, energy use in residential and commercial buildings has shifted away from fossil fuel combustion (predominantly natural gas) in favor of electricity use. The increase in electricity use may be the result of a greater use of air conditioning, electric heat, and appliances.
- The total emissions from energy consumption in the commercial sector fluctuated, ending with 2007 emissions at 2000 levels.
- The estimates for 2007 total emissions from industrial processes (i.e., emissions not associated with combustion) are only slightly higher than the 2000 emissions, 1.5 $MMTCO_2e$ vs. 1.4 $MMTCO_2e$, respectively. The use of ODS substitutes is now the leading source of GHG emissions from the industrial sector, replacing GHG emissions from semiconductor manufacturing. The contribution from the various sub-categories is reported in Section 6.
- Both the waste management and agricultural sectors showed small total increases in GHG emissions (0.6 and 0.4 $MMTCO_2e$, respectively). These estimates do not include emissions from consumption of fossil fuels (e.g., transportation, equipment operation, heaters, etc.).

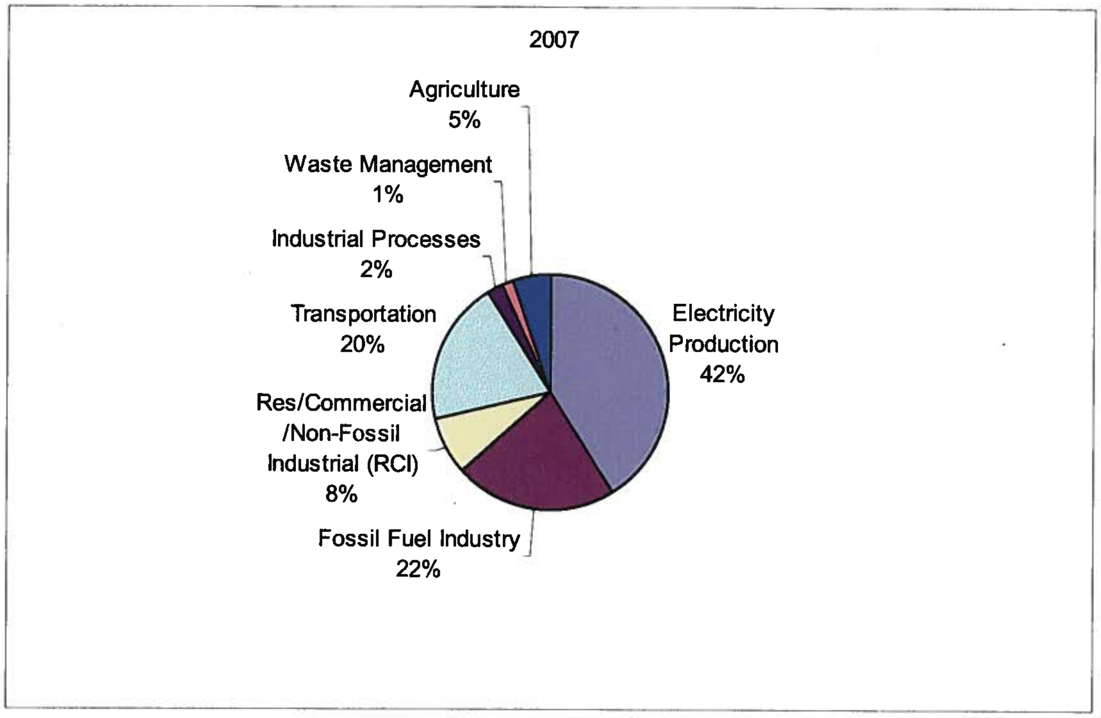
1.3 Evaluating Emissions on a Production Basis

To evaluate emissions on a production basis one must consider the total (gross) direct emissions from the activities of all sources in the state. A production-based analysis does not take into consideration the GHG emissions produced during the manufacture and transportation of products to the state, or adjust for the GHG emissions associated with electricity imported or exported across state lines. Table 2 summarizes the total direct emissions estimated in Sections 2 through 8 for each sector and Figure 1 illustrates the GHG emissions by sector. Note that while the estimates are rounded to one decimal point, the sums are based on the estimates prior to rounding and so might not reflect the sum of the rounded estimates. Table 1 provides the CCAG emissions estimates for 1990 and 2000, as well as the updated estimates for 2000 and 2007 using the methods described in this report.

Table 2 GHG Emissions for New Mexico Production Basis

GHG Emissions for New Mexico - Production Basis (Million Metric Tons CO2e)	1990 CCAG Estimate	2000 CCAG Estimate	2000 NMED Estimate	2007 NMED Estimate
Electricity Production	29.3	33.0	31.9	31.4
Coal	27.9	30.5	29.0	28.1
Natural Gas	1.4	2.5	2.9	3.3
Petroleum	0.0	0.0	0.0	0.0
Residential/Commercial /Non-Fossil Industrial (RCI)	7.0	7.3	6.6	6.2
Coal	0.1	0.2	0.2	0.2
Natural Gas	3.8	4.6	4.6	3.9
Petroleum	3.1	2.5	1.8	2.2
Transportation	11.0	14.2	13.5	15.1
Fossil Fuel Industry	15.2	19.5	19.3	16.9
Natural Gas Industry	12.7	17.0	17.2	13.9
Production	3.7	5.4	5.3	4.3
Processing	3.4	7.9	8.4	7.6
Transmission	5.2	3.3	3.3	1.6
Distribution	0.4	0.4	0.3	0.4
Oil Industry	2.3	2.3	1.9	1.9
Production	0.7	0.7	0.9	0.9
Refineries	1.6	1.6	1.0	1.0
Coal Mining (Methane)	0.2	0.2	0.2	1.1
Industrial Processes	0.5	1.5	1.5	1.5
ODS Substitutes	0.0	0.5	0.5	0.7
PFCs in Semi-conductor Ind.	0.1	0.5	0.5	0.2
SF6 from Electric Utilities	0.2	0.1	0.1	0.1
Cement & Other Industry	0.2	0.4	0.4	0.5
Waste Management	0.1	1.3	0.5	1.1
Solid Waste Management	0.0	1.0	0.3	0.9
Wastewater Management	0.1	0.3	0.2	0.2
Agriculture	2.3	6.0	3.6	4.0
Manure Management Mgmt & Enteric Fermentation (CH4)	1.8	3.5	3.1	3.5
Agricultural Soils (N2O)	0.5	2.4	0.5	0.5
Total Gross Emissions	65.3	82.7	77.0	76.2

Figure 1: 2007 New Mexico GHG Emissions by Sector



1.4 Evaluating Emissions on a Consumption Basis

The majority of GHG emissions in New Mexico are the result of the coal-based electricity generation and fossil fuel industries, a significant fraction of which meets the needs in other states. As noted in the CCAG Report, this situation raises an important question with respect to how these emissions should be addressed from an accounting and policy basis. Section 1.3 presents New Mexico emissions on a production basis, which is to say the total gross emissions of GHG from New Mexico. Another approach is to evaluate New Mexico emissions on a consumption basis, which would reflect the emissions resulting from the consumption of energy (both fossil fuels and electricity) in each sector.

Reporting on a consumption basis has the advantage of showing the extent to which GHG reduction initiatives and other influences have changed energy consumption patterns in the state, to better inform policy makers who may be evaluating future initiatives. In addition, the 'carbon footprint' of each sector is more accurately presented by including the emissions that occurred as a result of the electricity consumption by that sector[9], along with each sector's direct emissions from combustion and process emissions. In a consumption-based evaluation of emissions, the emissions from electricity production are attributed to the sectors within the state that consume the electricity, with the emissions

[9] The 'carbon content' of electricity used in New Mexico is estimated in this report (as in the CCAG report) as the total emissions from electricity production in the state in a given year, divided by the total electricity produced in the state during that year. While the carbon content of imported electricity may be different, data are not available for estimating imported electricity. However, imported electricity accounts for only a small portion of electricity use in New Mexico.

that occurred during production of exported electricity reported as a separate category within the industrial sector. Thus the total emissions reported in Section 1.3 are included in this evaluation, although the attribution shifts.

Figure 2 illustrates the consumption based emissions in New Mexico for the years 1990, 2000 and 2007. This figure divides emissions into (1) transportation emissions (which include emissions from fleets, farm equipment, and personal transport), (2) emissions from energy use in buildings, and (3) emissions from the industrial sector (not including fleets). These represent the three general areas of activity that result in GHG emissions.

Figure 2 Consumption Based GHG Emissions

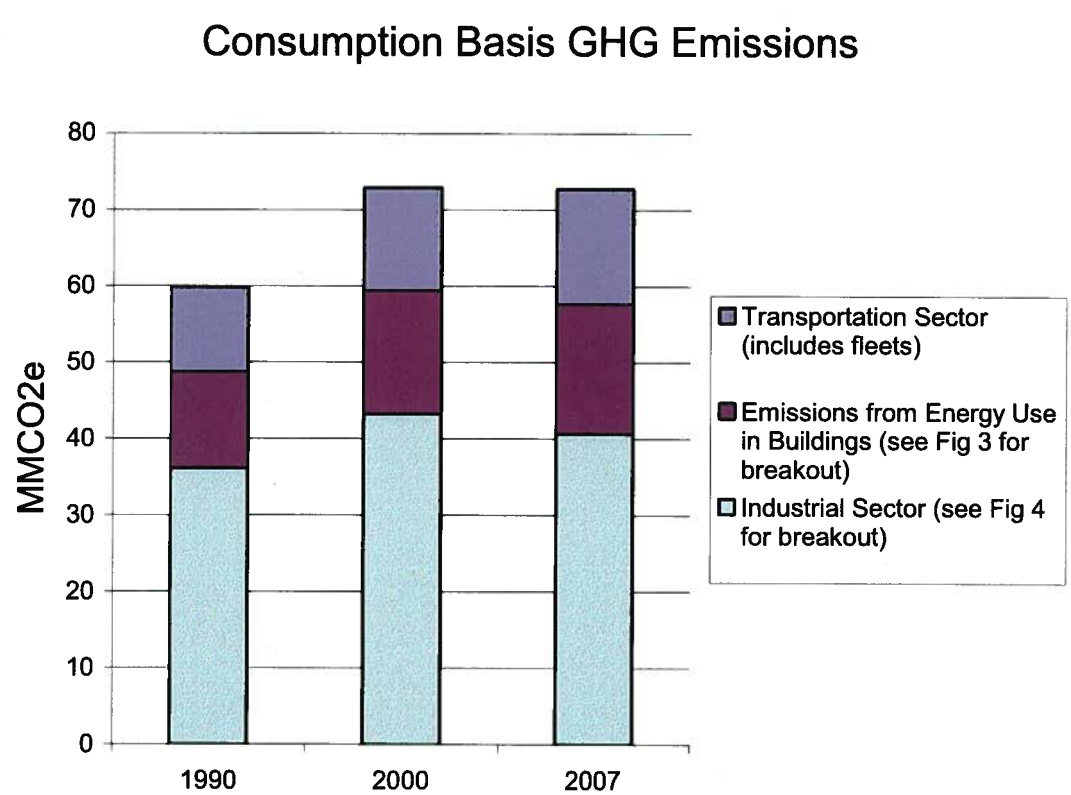


Figure 15 (in Section 4, which further discusses the transportation sector) compares emissions from diesel, gasoline and aviation fuels from 2000 to 2007. During the period 2000-2007, the estimated emissions from gasoline consumption increased by 4%. However, during this time, the state population grew 6.7%[10], resulting in a 2.5% drop in per capita emissions from gasoline use. Several factors may have contributed to this drop of average gasoline usage per person. As newer vehicles are purchased, the average gas mileage rate for vehicles in the state may have improved, and increases in gasoline prices

[10] From the US Census Bureau's annual population estimates from 4/1/00 to 7/1/07 (NST-EST2007), released 12/27/07.

and use of public transportation may have resulted in less driving. However, data that would support or quantify such trends is not available at the time of this report.

Emissions from diesel fuel use rose by 28% between 2000 and 2007. This rise reflects the increase in freight traffic anticipated in the New Mexico 2025 Statewide Multimodal Transportation Plan (released in 2005) and reflected in CCAG projections. The Transportation Plan estimated that 85% of commercial traffic on I-10 and I-40 was simply crossing the state, without delivering or picking up any freight, and anticipated that such freight traffic would increase over time because these interstate highways connect to Southern California.

Figure 3 provides greater detail regarding emissions that result from energy use in buildings. These emissions are attributed to the residential and commercial sectors, which consume energy to heat and cool buildings and to power lights and appliances. As shown in Figure 3, electricity use accounts for a larger share of GHG emissions in these sectors than the direct combustion of fossil fuels. Between 2000 and 2007, the indirect emissions from the consumption of electricity in the residential and commercial sectors increased by 22% and 1%, respectively, and the indirect emissions from the consumption of electricity in the industrial sector (including the fossil fuel industry) increased by 19%. Taking electricity consumption into account, the residential sector increased emissions from energy use by a total of 13% (taking into account the state's growing population, this is a per capita increase of 6%). During the same period, the total emissions from energy consumption in the commercial sector remained constant. The RCI sector is further discussed in Section 5.

Figure 4 provides greater detail regarding emissions that result from activities in the industrial sector. These activities are further discussed in Section 2 (Fossil fuel Industry), Section 5 [Emissions from Fossil Fuel Combustion in the Residential, Commercial, and (Non-Fossil Fuel Industry) Industrial Sectors] and Sections 6 through 8 (which estimate process emissions). Emissions from the production of electricity are addressed in Section 3.

Figure 3 Consumption Basis Emissions from Energy Use in Buildings

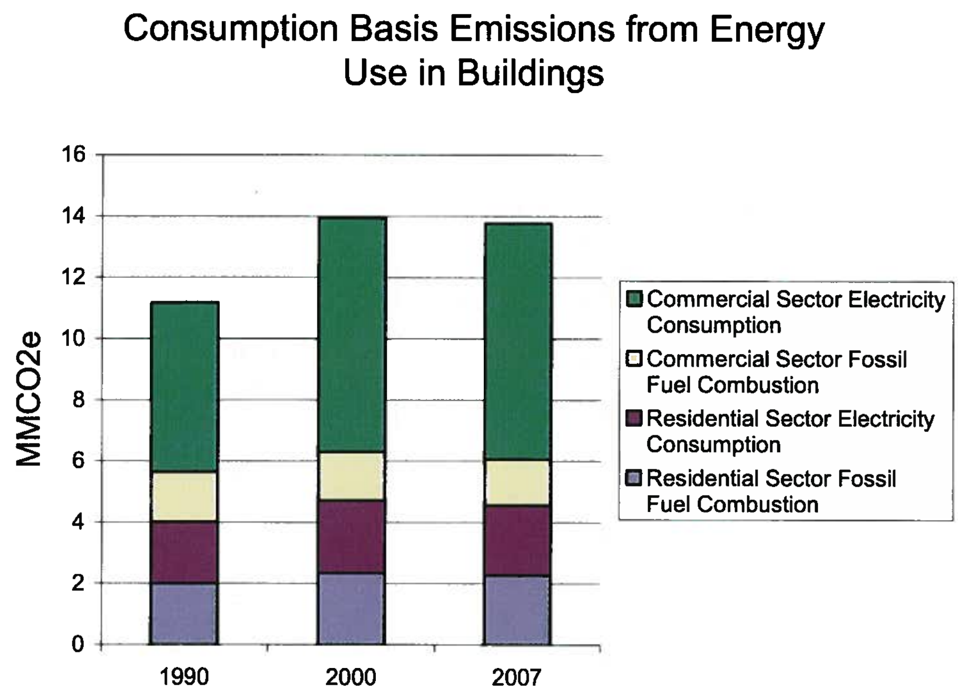
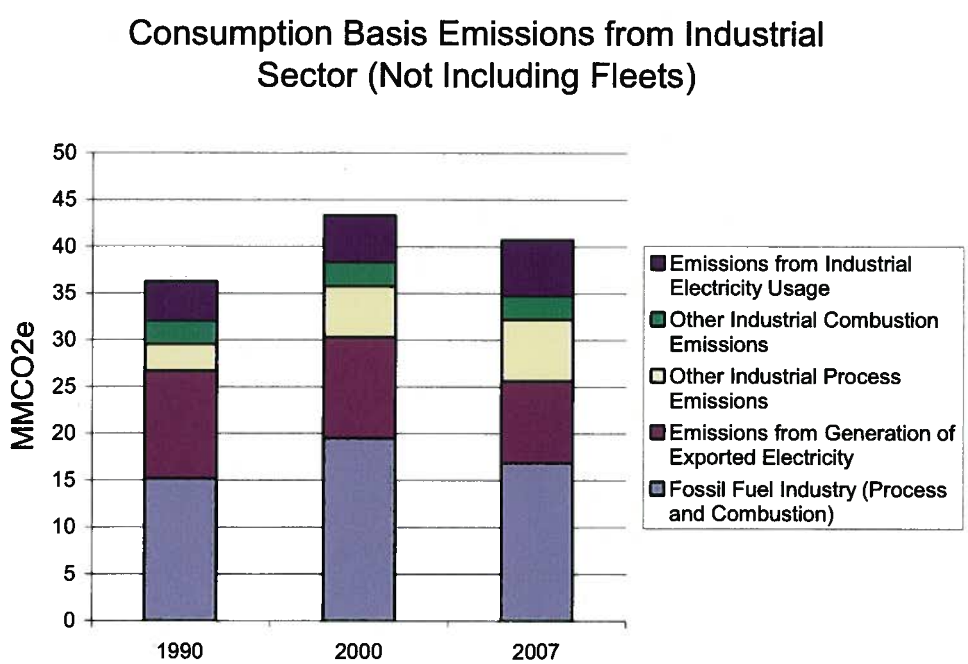


Figure 4 Consumption Basis Emissions from Industrial Sector



1.5 Evaluating Emissions on a Per Capita Basis

Per capita emissions estimates do not reflect the sum of the carbon footprints of the residents of that locality. In addition to in-state electricity and fuel use, the carbon footprint of an individual or family includes emissions that result from out-of-state travel and the emissions that result from the manufacture and transport of products purchased by that individual or family[11]. Conversely, a per capita estimate of emissions in a state divides the total emissions from residential, commercial, transportation and industrial emissions by the population of the state. By doing so, per capita emissions estimates remove the factor of increasing state population from emissions comparisons.

In New Mexico, the total State GHG emissions includes those that result from producing significant amounts of electricity used by consumers in other states, and significant emissions from the production, refining and transport of oil and natural gas. When comparing the per capita emissions of different states, to include emissions associated with exported electricity in the per capita estimate for New Mexico may cause those emissions to be double counted, because the per capita emissions for electricity importing states are likely to take into account the emissions from production of the imported electricity[12]. Thus, this report, consistent with the CCAG Report, estimates per capita emissions as the sum of the total emissions less the emissions associated with production of exported electricity, divided by the state population. For 2007, the per capita emissions for New Mexico were 35 metric tons of CO_2e per person.

Data indicate that between 2000 and 2007, New Mexicans reduced their average emissions from gasoline use by 2.5% and increased their consumption of energy in heating, cooling and powering residential buildings by 6% (see Section 1.2 above). Over time, energy use in buildings has trended towards a reduction in fossil fuel combustion (predominantly natural gas) and an increase in electricity use. The increase in electricity use may be the result of a greater use of air conditioning, electric heat, and appliances.

1.6 Emissions Estimation Approach and Variations from Methods in the CCAG Report

In its simplest form, emissions inventories are performed by summing the calculated emissions estimates for the specific source categories that are present. Emissions for specific source categories are estimated by multiplying activity factors (e.g., gasoline purchased, coal consumed) by emissions factors. Emissions factors can be developed using information about chemical properties (e.g., the amount of carbon in a given amount of a particular type of coal) and studies (e.g., the percentage of carbon that is retained in fly ash after combustion of coal). The assumptions used in developing emissions factors can introduce significant uncertainty. Additional uncertainty can be introduced in the activity factors, due to inaccuracies that can be inherent in the measurement process (e.g., vehicle miles traveled in the state, percentage of yard waste in land fills).

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[11] http://www.epa.gov/climatechange/emissions/ind_calculator.html

[12] New Mexico both imports and exports electricity, with a net export of electricity produced. See Section 3.

In order to maintain consistency to the extent possible with other emissions estimates, NMED has used the US EPA SIT for state inventories[13] as a starting point. The approach used by the US EPA in its national GHG emissions inventory and guidelines for states was developed based on guidelines from the Intergovernmental Panel on Climate Change[14], the international organization responsible for developing coordinated methods for national GHG inventories. The initial estimates based on the US EPA SIT were then augmented to conform to local data and conditions, as informed by New Mexico-specific source data, experts, and methodologies developed for the CCAG Report.

In cases where data sources may conflict, a higher priority was placed on local and state data analyses, with national data used as defaults where necessary. Priority was also given to larger emissions source categories, such as the fossil fuel production sector, and as a result sectors with relatively small emissions levels may not be reported in the same level of detail as other activities. Specific details regarding estimation of emissions from specific sectors are included in the following sections.

2 Fossil Fuel Industry (Oil, Gas, and Coal)

2.1 Emissions 2000-2007

Total NM GHG emissions from this sector decreased by 2.2 $MMTCO_2e$ from 2000 (19.1 $MMTCO_2e$) to 2007 (16.9 $MMTCO_2e$). This reduction is primarily attributable to decreases in methane emissions from natural gas production, processing and transmission.

2.2 Estimation Methodology & Data Sources

The general approach used for this update was to follow the methodologies used in the original CCAG inventory where possible, using updated data for recent years and in some cases recalculated data for years prior to 2004.

For methane emissions from the natural gas and petroleum industries, it was not possible to follow exactly the CCAG methodologies because not all the necessary spreadsheets used in the CCAG inventory were provided to NMED by the contractor. In these cases, we attempted to follow as closely as possible the methods and data sources as generally described in the narrative text of CCAG report.

For the updated emissions in this report, methane emissions from oil and gas operations were calculated for five subsectors:

1) Natural gas production;
2) Natural gas processing;
3) Natural gas transmission;
4) Natural gas distribution; and
5) Oil production and refining.

[13] http://www.epa.gov/climatechange/emissions/state_guidance.html
[14] http://www.ipcc-nggip.iges.or.jp/

For the natural gas subsectors 1 through 3 above, emissions were calculated using the following formula:

Equation 1

$$NM\ emissions = US\ emissions \times \left(\frac{NM\ activity}{US\ activity} \right)$$

The activity measures for each subsector are given in Table 3.

Table 3: Activity Measures Used in Calculation of Natural Gas Subsector Methane Emissions

Natural Gas Subsector	Activity Measure (NM and US)
Natural Gas Production	Marketed Production Volume
Natural Gas Processing	Volume of Natural Gas Processed
Natural Gas Transmission	Transmission Pipeline Mileage

Data source: US Department of Energy, Energy Information Administration (EIA).

This method is based on the simplistic assumption that emissions per unit of activity are always the same in New Mexico as at the national level, and does not account for any differences in gas reservoir characteristics, operational practices, or implementation of emissions reductions measures.

The values for U.S. emissions in Equation 1 are derived from the US EPA annual GHG emissions inventories. As described in the most recent report[15], methods for estimating methane emissions from the oil and gas industry are periodically revised and emissions values for some earlier years are recalculated. This recalculation of national values alters the values for earlier years in the NM inventory when Equation 1 is used.

The CCAG report described the method for calculating methane emissions from natural gas distribution as following Eq. 1, with natural gas consumption as the activity metric. However, none of the EIA consumption metrics we tested would reproduce the CCAG data for this subsector. Therefore, for this update we used the methods in the SIT. Input data obtained from the US Department of Transportation Pipeline and Hazardous Materials Safety Administration[16] included miles of distribution lines and number of services.

Methane emissions from oil production, refining and transportation (aggregated under the category "Oil Production" in the CCAG report) were calculated using the SIT, which followed the method stated to have been used for the CCAG report. Input data obtained from EIA included oil production and refinery input, with the amount transported assumed to be the same as refinery input.

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[15] Annex 3 of the US EPA report "Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2007" (April 2009).

[16] http://www.phmsa.dot.gov/portal/site/PHMSA/menuitem.ebdc7a8a7e39f2e55cf2031050248a0c/?vgnextoid=a872dfa122a1d110VgnVCM1000009ed07898RCRD&vgnextchannel=3430fb649a2dc110VgnVCM1000009ed07898RCRD&vgnextfmt=print

Methane emissions from coal mining were obtained from state-specific data in the US EPA report "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2007".[17]

Carbon dioxide emissions from fuel combustion were calculated for the following subsectors:

1) Natural gas production;
2) Natural gas processing;
3) Natural gas transmission; and
4) Petroleum refineries.

Key input data for the natural gas industry sources were obtained from EIA: Lease Fuel Consumption (production), Plant Fuel Consumption (processing), and Natural Gas Consumed as Pipeline Fuel (transmission). For petroleum refinery fuel use, the CCAG Report assumed a constant level of fuel use CO_2 emissions (1.6 $MMTCO_2e$ based on permit limits. However, emission reporting of actual fuel use CO_2 emissions for 2008 gave a smaller value of 1.0 $MMTCO_2e$ for estimated total refinery emissions. For this report, we also assumed that fuel use levels were constant, and estimated emissions for 2000 and 2007 at 1.0 $MMTCO_2e$.

An additional source of CO_2 emissions is the venting of CO_2 removed from natural gas during processing. This source is especially significant in the processing of coal bed methane, which in New Mexico commonly contains in excess of 10% CO_2. NMED followed the CCAG methodology in estimating these emissions using a mass balance approach. Emissions were calculated as the product of volume of coal bed methane produced from the San Juan Basin (data from the Oil Conservation Division of the New Mexico Energy, Minerals and Natural Resources Department) and the estimated concentration of CO_2 at the gas plant inlet. CO_2 concentration was estimated by the CCAG inventory using a linear fit to concentration values over the period 1998-2002. NMED was unable to obtain updated CO_2 concentration data for this report, and therefore continued use of the extrapolated values based on the CCAG regression.

2.3 Comparative Analysis

The most significant change in the contribution of major sectors (natural gas, oil, and coal mining methane) from the CCAG Report data to the 2007 Update is the increase in the percentage of fossil fuel industry emissions from coal mining methane (see Figure 5).This source of emissions had already begun a sharp increase from 2000 to 2003, and the increase continued through 2005 (see Figure 6). Total coal production in New Mexico has decreased slightly since 2000,[18] but a new underground mine was developed at the site of a former surface mine[19]. Underground mine production rose from near zero in 2000 to around 27-28% of total production in 2004-2008[20]. Ventilation and degasification

[17] Annex 3 of the US EPA report "Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2007" (April 2009).

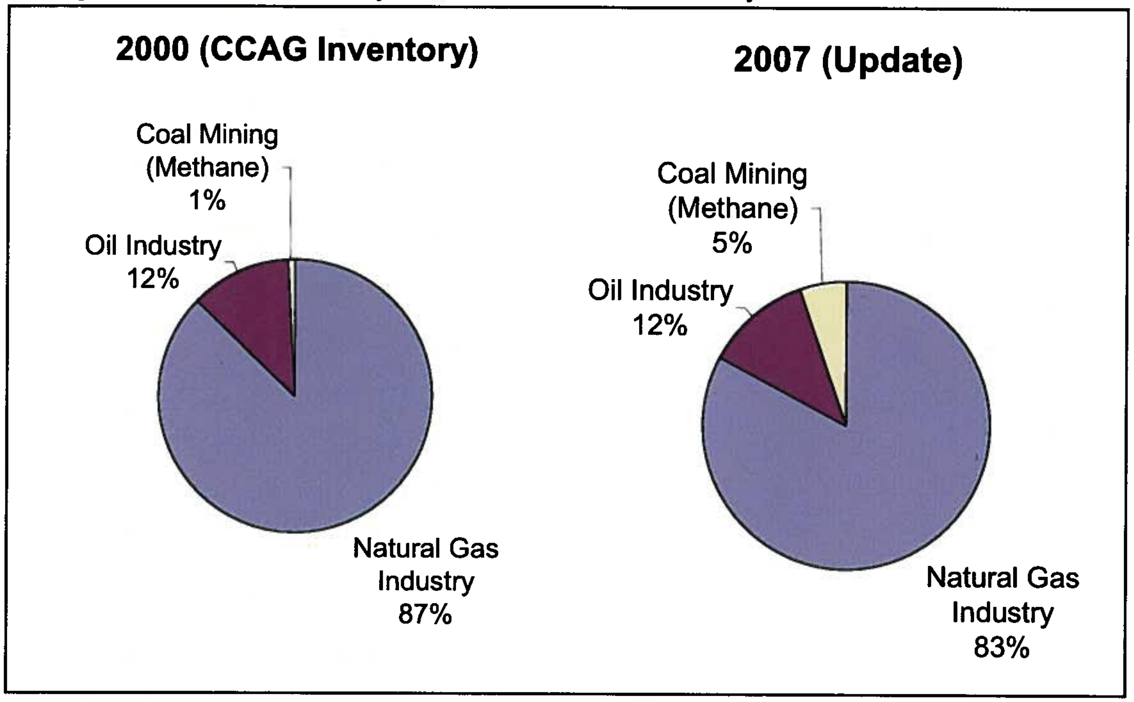
[18] EIA Coal Industry Annuals, www.eia.doe.gov/cneaf/coal/page/acr/backissues.html

[19] [BHP Billiton, New Mexico Coal, www.bhpbilliton.com/bb/ourBusinesses/energyCoal/newMexicoCoal.jsp].

[20] EIA Coal Industry Annuals, www.eia.doe.gov/cneaf/coal/page/acr/backissues.html.

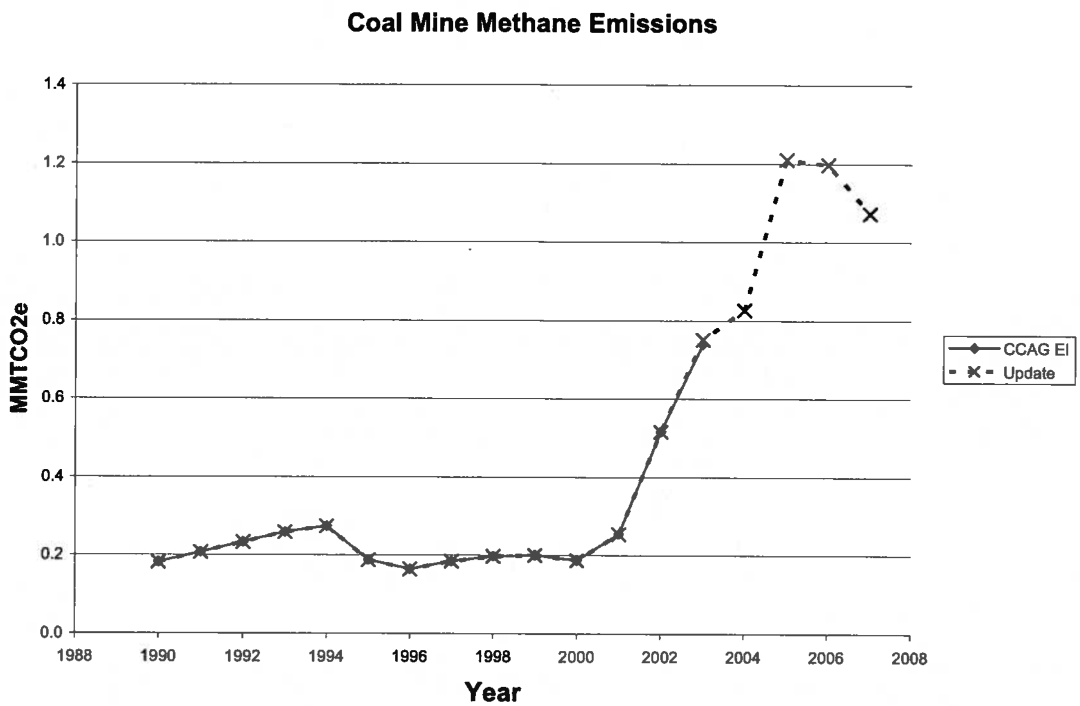
of underground mines results in higher methane emissions per ton of coal produced[21]. Therefore the increase in methane emissions from coal mining has resulted from the increase in underground mining in New Mexico over the last 7 years (see Figure 5).

Figure 5 Contributions of Major Sectors to Fossil Fuels Industry Emissions



[21] EPA, Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2007, Annex 3.

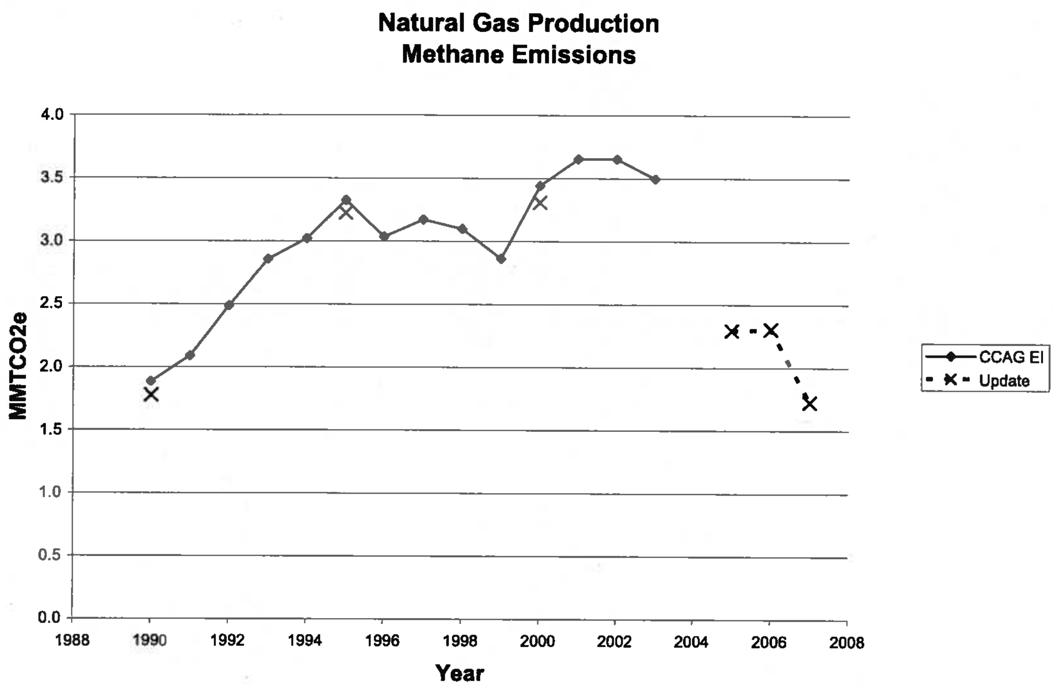
Figure 6 Coal Mining Methane Emissions: Comparison of CCAG Report to 2007 Update



Methane emissions from natural gas distribution appear to have decreased substantially since 2000 (see Figure 7). This decrease is primarily due to the decrease in national emissions from this source rather than in the proportional contribution of NM to US production (see Eq. 1).

The US EPA may be overestimating methane emissions reductions from natural gas production. Their methodology is 1) calculate an updated baseline emissions value based on an earlier study, and then 2) subtract the industry-reported emissions reductions from the Natural Gas STAR program. Although the baseline emissions study estimated that well completion emissions were negligible, reduced emissions from well completions have been a substantial fraction of reported Natural Gas STAR reductions in recent years. This indicates that emissions from this source were substantially underestimated in earlier years, and the decrease in emissions in recent years has been overestimated. Since the NM inventory for this source is calculated as a fraction of the US emissions, this error in the EPA inventory would also affect the NM trends.

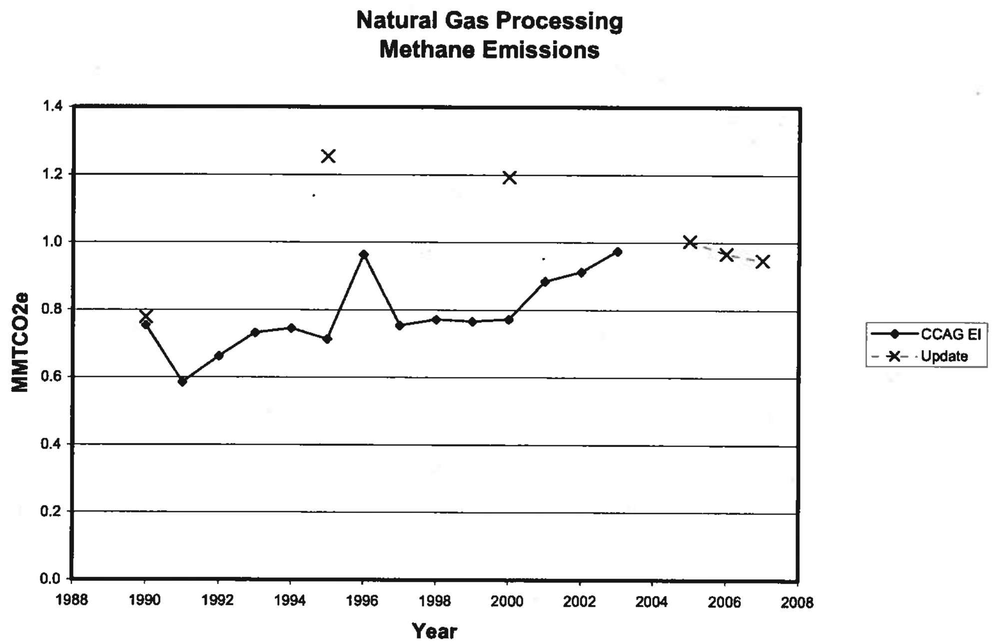
Figure 7 Natural Gas Production Methane Emissions: Comparison of CCAG Report and 2007 Update



Methane emissions from natural gas processing have also decreased, relative to the recalculated 2000 value (see Figure 8).

Figure 8 Natural Gas Processing Methane Emissions: Comparison of CCAG Report and 2007 Update

Differences between the inventory values for 2001-2003 reflect differences in methods used by EPA to calculate national emissions from this category, on which the calculation of New Mexico emissions is based.

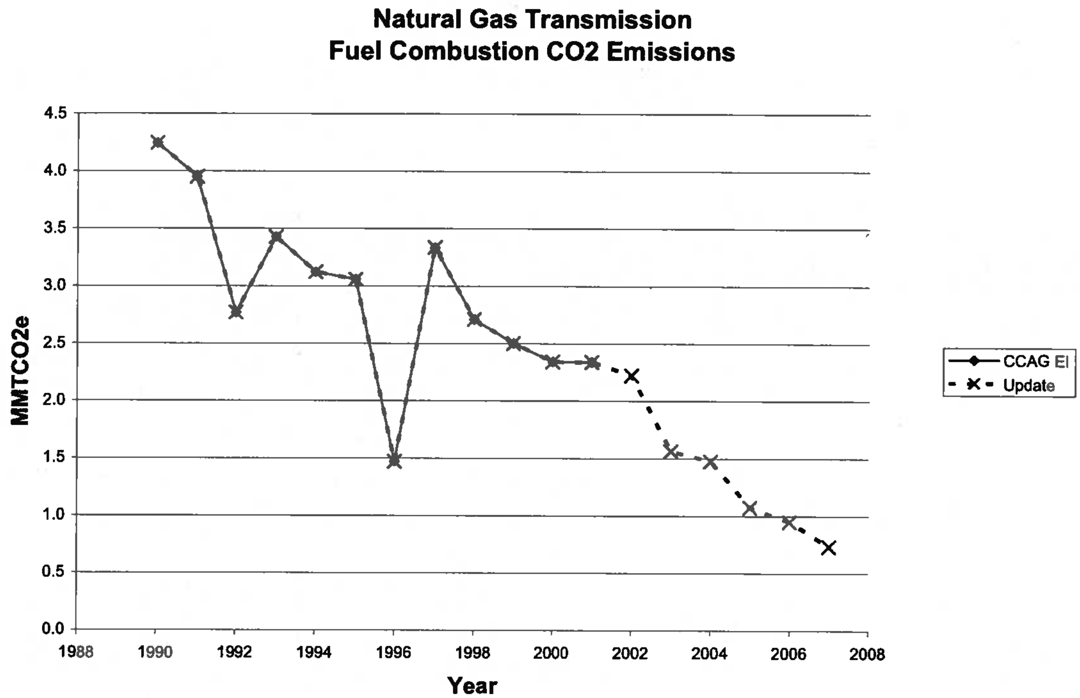


Among fossil fuel industry combustion CO_2 sources, the most dramatic long-term trend in emissions has been the apparent decrease in estimated emissions from natural gas transmission (see Figure 9). We do not believe these data accurately reflect trends in this emissions source. Gas production and processing volumes have not decreased dramatically, and the New Mexico Air Quality Bureau has not noted such a great decrease in the number or activity of large compressor stations. Emissions calculation methods are simple; the only data input is the fuel consumption reported by EIA, which is in turn compiled from company reports to that agency.

NMED examined company reports to EIA and found that in earlier years (such as year 2000), some upstream and midstream companies were reporting a significant portion of compressor fuel use, but in more recent years these companies did not report consumption in this category. One midstream company reported disposition of about 25 billion cubic feet of gas (equivalent to about 1.75 $MMTCO_2$) as "Other – vented and flared" rather than as Lease Fuel, Processing Plant, or Pipeline Fuel Use; this gas consumption would not be accounted for by the current inventory methods, which use Lease Fuel, Processing Plant, or Pipeline Fuel Use as specific data inputs from EIA. We conclude that reliance on EIA data as the input for calculation of fuel combustion emissions in the oil and gas industry sector is likely to result in significant error.

Figure 9 Natural Gas Transmission Methane Emissions: Comparison of CCAG Report to 2007 Update

Decreases since year 2000 resulted in large part from changes in how data were reported to EIA.



2.4 Significant issues

Coal mining methane emissions primarily from ventilation and degasification have grown considerably over the last seven years. This source was relatively insignificant in earlier years, but now deserves more attention in regard to emissions inventory and possible emissions controls.

2.5 Key Uncertainties

Natural gas industry methane emissions are calculated by simplistic methods which are incapable of responding to state-specific factors that might cause emissions intensity (emissions per unit of activity) in NM to be higher or lower than the national average.

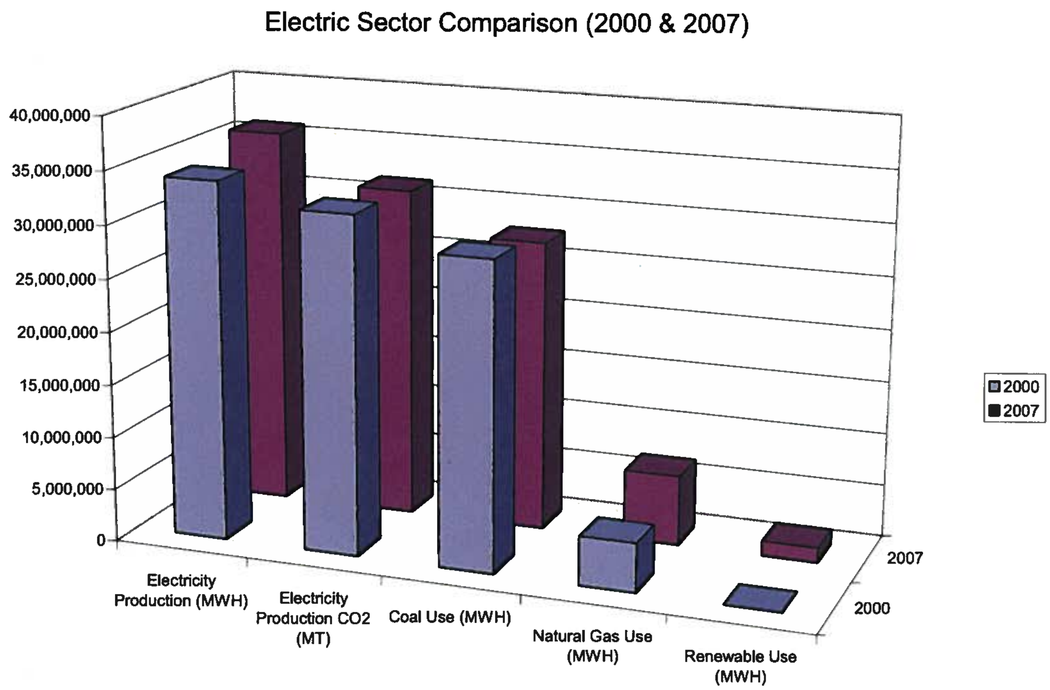
Reliance on EIA data to calculate fuel combustion emissions for the sector as a whole and for individual subsectors is likely to result in significant error, because of inconsistencies in company reporting to EIA and in EIA classification of fuels use.

3 Electricity Production

3.1 Emissions 2000-2007

The electric generating sector continues to be the dominant source of GHG emissions in New Mexico. Although the contributions from coal-fired power plants hovers around 90% of the total GHG emissions from this sector, the State has realized an increase in the supply of low- or zero-GHG emitting electric power during the past four years. The supply of electricity from natural gas and renewable energy as a percent of the total energy produced increased by approximately 36 and 156 percent respectively from 2000 to 2007[22] (see Figure 10) This trend is explained in part by the increase of natural gas generating capacity that was constructed in the early part of the decade and efforts by electric generating utilities to comply with the state's Renewable Portfolio Standard (RPS). The trend of additional electricity generated from low- or zero-emitting sources may be enhanced further with the establishment of a carbon cap and trade regulatory scheme.

Figure 10 Electric Sector Comparison



The supply of electricity produced increased approximately 8% from the four year periods 2000 – 2003 and 2004 – 2007[23]. Total retail sales increased by approximately 11% over the same time period (see Figure 11). Commercial and industrial sector electricity consumption increased by approximately 19% each, and by 16% in the residential sector. Retail sales continue to constitute approximately 60% of supply, reflecting the fact that New Mexico exports a significant amount of power to other western states (see Figure 11).

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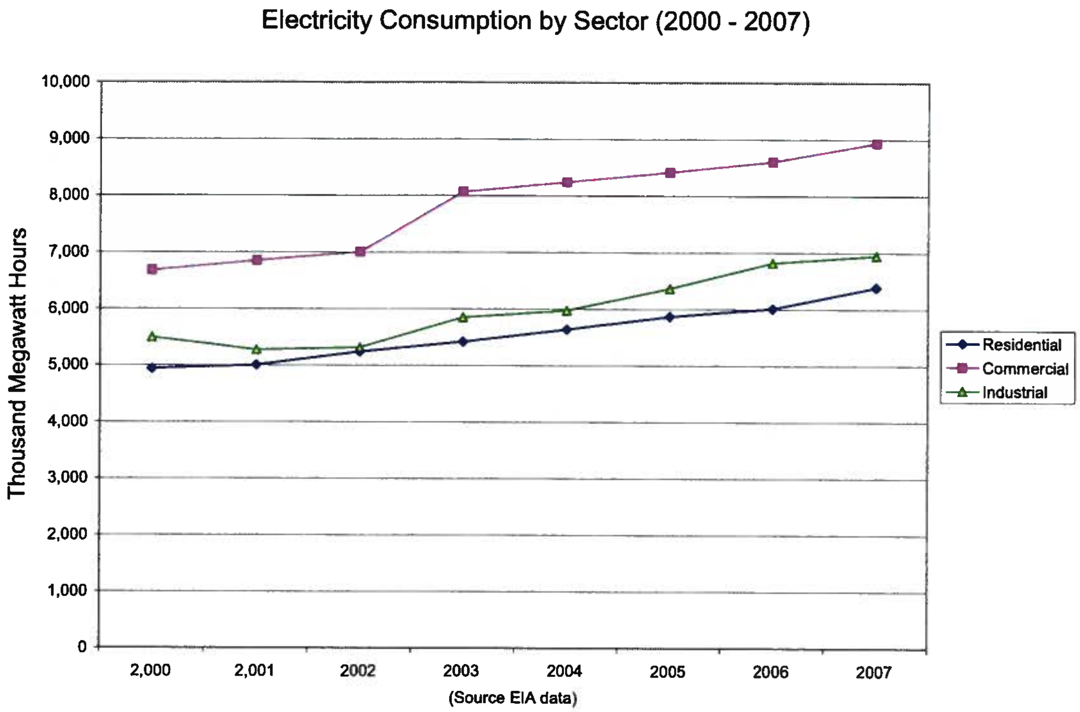
[22] 2007 - New Mexico Electricity Profile DOE/EIA-0348(01)/2

[23] Ibid.

Figure 11 Electricity Consumption by Sector



New Mexico continues to export 30-40% of the total net electricity generated (see Figure 12)[24]. Electricity exports as a percent of total electricity supply peaked at 40% at the beginning of the decade, declined to a low of 30% in 2003, and has generally risen towards 2000 levels. Consumption data include an adjustment to reflect 10% power losses from transmission and distribution. In the near term, it's expected that New Mexico will continue to export significant power to the western electric grid.

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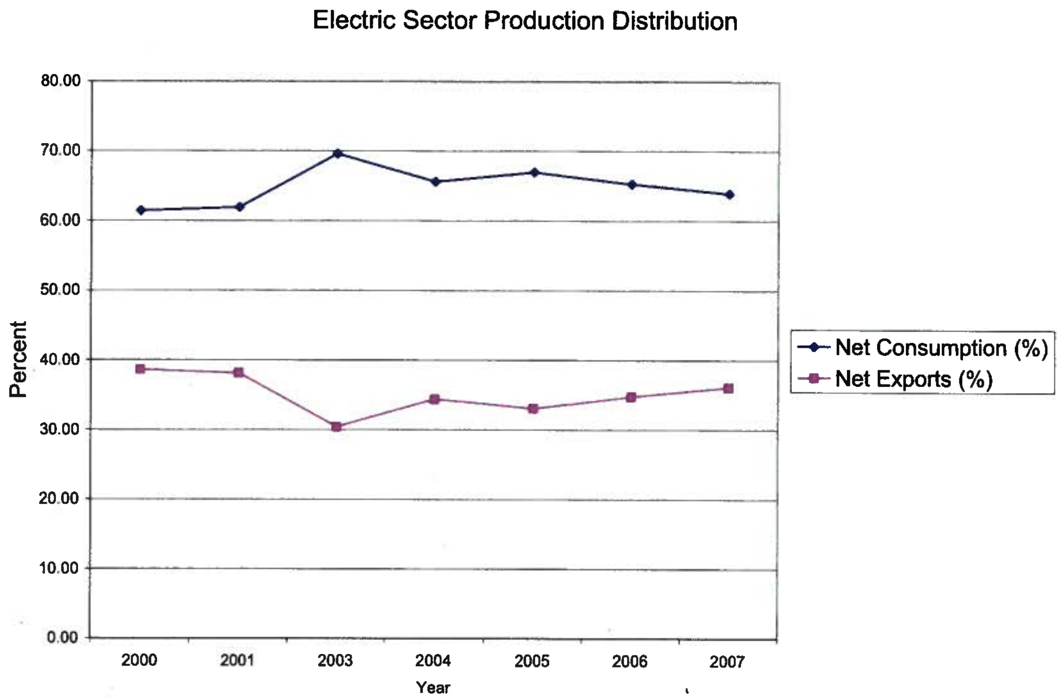
[24] Ibid.

Figure 12 Electric Sector Production Distribution



3.2 Estimation Methodology & Data Sources

The data sources in Table 4 were considered to evaluate electric sector GHG emissions: EPA EGRID, EIA's New Mexico SEDS and 923 data reports, EPA's Clean Air Markets Division, and EPA's State Emissions Tool. EGRID data were not used for this analysis as it did not include 2006 and 2007 data. EIA's SEDS data resulted in emissions estimated approximately 3% greater than EPA's SIT and 6.5% greater than EPA's Clean Air Markets data (CAMD). EIA's SEDS emissions data were chosen for this analysis because of the comprehensive nature of the data source (EIA data includes electricity production, exports, consumption and emissions by fuel type) which facilitated a relative comparison to the approach used in the CCAG report for those parameters[25].

Table 4 Electric Sector Data Source Comparison 2004-2008

$MMTCO_{2e}$	2004	2005	2006	2007	2008
EPA Clean Air Markets	29.4	30.57	31.18	29.28	29.87
State Inventory Tool [26]	30.43	31.76	32.37	30.83	31.27
EPA EGRID [27]	32.81	34.1	--	--	--
EIA Estimated [28]	31.27	32.74	33.05	31.45	NA

[25] Ibid.

[26] 2008 SIT estimate from EIA 923 monthly time series files.

[27] Data not available 2006 – 2008

[28] Data source http://www.eia.doe.gov/cneaf/electricity/st_profiles/sept07nm.xls

The apparent consistency between the SIT and EIA emission estimates is reflective of the fact that EIA energy consumption data are used as data input for the SIT. The difference between EIA data and EPA CAMD data is that EPA's Acid Rain Program does not apply to all sources required to report to EIA.

3.3 Comparative Analysis

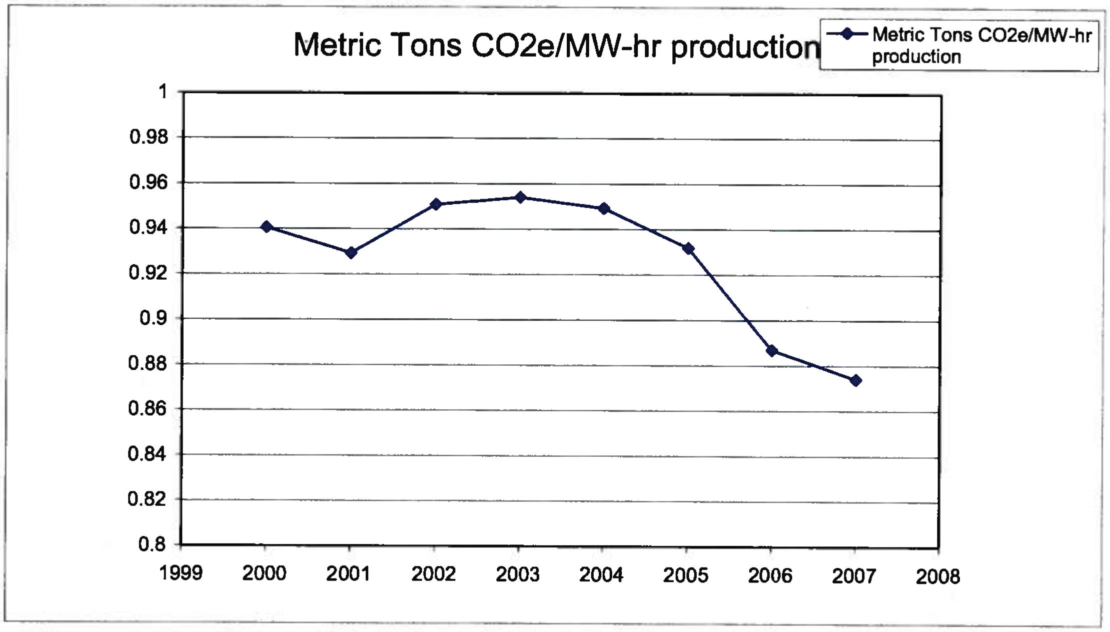
The CCAG report noted there was approximately 2500 MW of proposed new power plants, with the majority of those projects using coal to generate electricity. Two of the major power projects in development were Desert Rock (1500 MW) and Mustang Generating Station (350 MW). It was expected that the approval and construction of these two projects would result in emissions increases upwards of 15 $MMtCO_2$. However, the Mustang project application was withdrawn by the permit applicant on October 4, 2006, and the Desert Rock permit remanded by EPA's Environmental Appeals Board back to EPA Region IX on September 25, 2009 to require the consideration of carbon sequestration technology as BACT. EPA's recent New Source Review proposed rule change requiring the installation of BACT to address GHG emissions from major stationary sources such as Desert Rock will likely impact additional near-term coal based electric generation, as the technology has been applied on a very limited basis.

Non-coal derived electric generation in New Mexico has been on the rise since 2003. Natural gas capacity increased by approximately 600 MW; wind generation capacity nearly doubled to approximately 600 MW; and two significant solar projects totaling 122 MW are planned to be implemented by 2011. Additional renewable energy projects will be forthcoming in the next decade as New Mexico has positioned itself well to capitalize on these resources. New Mexico law (Title 17, Chapter 9, Part 573) requires regulated utilities to diversify their generation portfolios.

3.4 Significant Issues

The continued development of renewable energy sources, availability of clean coal technology, and state and national economic conditions will affect near and long term growth and subsequent emissions from this sector (see Figure 13).

Figure 13: Metric Tons CO2e/MW-hr Production[29]



Unlike smaller sources of GHG emissions, significant resources and time are required to obtain environmental permits to construct and operate power plants. Near term lower natural gas prices may foster increased utilization of existing capacity and perhaps spur new natural gas power generation projects. Increased natural gas and renewable energy projects would continue to reduce carbon intensity from this sector.

However, development of electric grid infrastructure to connect renewable sources of energy to end users will continue to be a factor. The uncertainties related to the availability, acceptance and reliability of clean coal technologies in light of the vast supply of coal in New Mexico are also noteworthy.

3.5 Key Uncertainties

According to the uncertainty discussion associated with the SIT, "many different factors introduce uncertainties into estimating emissions from imports and exports of electricity. The precise fuel mix used to generate the power crossing state lines is very difficult to determine due to the highly complex nature of electricity flow through the US power grid. Therefore, an average fuel mix for all electricity generation within a specific region of the grid must usually be used. Moreover, these emission factors are generated by emission monitors (rather than carbon contents of fuels), which may overestimate CO_2 emissions to a small extent."[30] This inventory update did not attempt to differentiate between the fuel type and associated emissions from electricity exports and did not include an evaluation of electricity imports for the reasons stated above. However, it's likely that a large amount of exported electric generation is coal based.

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[29] Ibid.

[30] SIT 2008, Electricity Sector Uncertainties Discussion

4 Transportation

4.1 Emissions 1990-2007

As noted in the CCAG report, the transportation sector is the third largest source of GHG emissions in New Mexico. Large distances and a dispersed population lead to high transportation demand.

Figure 14 Transportation Sector Emissions includes the total transportation sector emissions for the years 2000 to 2007 (see Section 4.2 below for a discussion of data sources). Between 2000 and 2007, GHG emissions from the transportation sector increased 12%. This increase was due to a combination of factors, including increased freight traffic and increased state population.

Figure 14 Transportation Sector Emissions

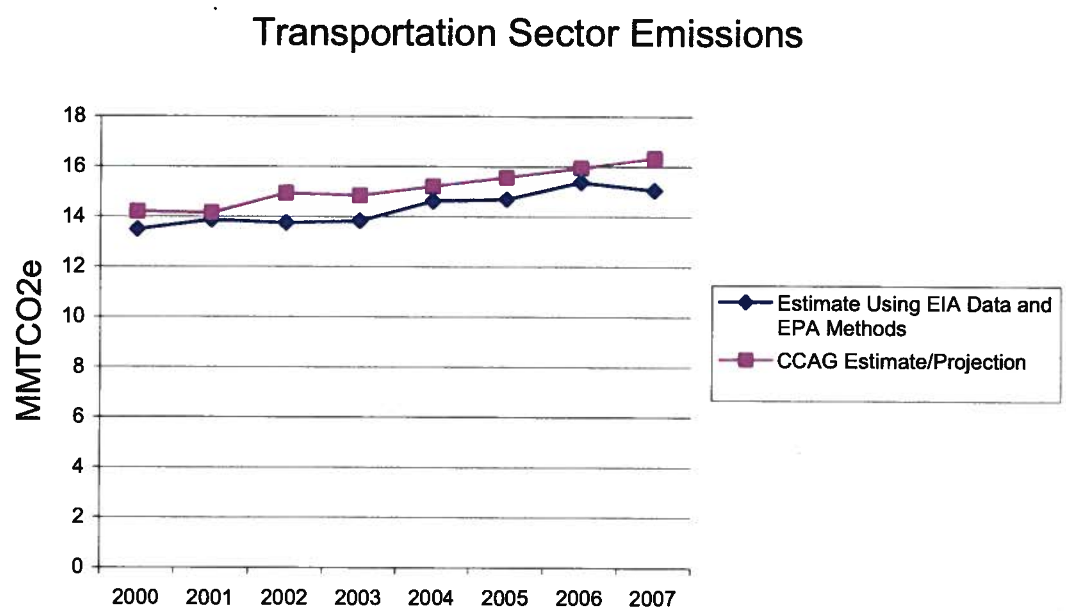
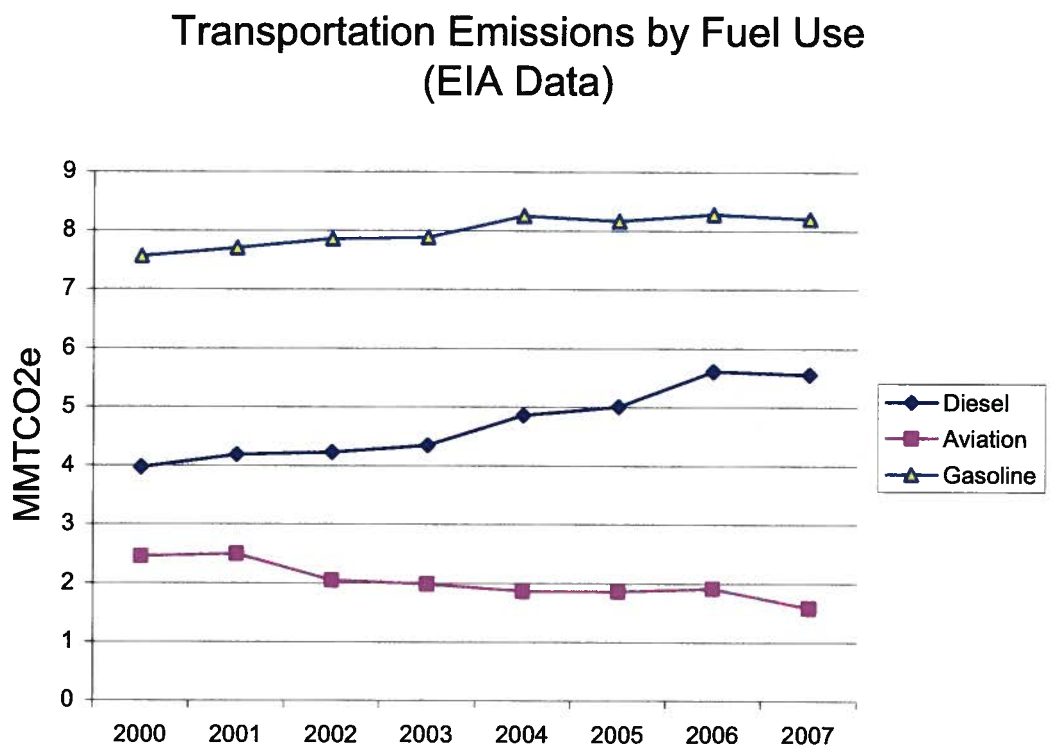


Figure 15 compares the amount of gasoline, diesel, and aviation fuel use from 2000 to 2007, using EIA data (emissions from other fuels are too low to be reflected in this figure). The 28% increase in emissions from diesel fuel use between 2000 and 2007 reflects the increase in freight traffic anticipated in the New Mexico 2025 Statewide Multimodal Transportation Plan (released in 2005) and reflected in CCAG projections. The Transportation Plan estimated that 85% of commercial traffic on I-10 and I-40 was simply crossing the state, without delivering or picking up any freight, and that such freight traffic would increase over time.

Figure 15 Transportation Sector Emissions by Fuel Use



During the period 2000-2007, the estimated emissions from gasoline consumption increased by 4%. However, during this time, the state population grew 6.7%, resulting in a drop of 2.5% in per capita emissions from gasoline use. Several factors may have contributed to this drop of average gasoline usage per person. As newer vehicles are purchased, the average gas mileage rate for vehicles in the state may have improved, and increases in gasoline prices and use of public transportation may have resulted in less driving. However, data that would support or quantify such trends is not available at the time of this report.

EIA data indicates that emissions from aviation fuel use in the state dropped 20% from 2000 to 2007, primarily as a result of a drop in jet fuel consumed. The EIA data reflects consumption of aviation gasoline and jet fuel by both the public sector and the military.

4.2 Estimation Methodology & Data Sources

The transportation data used in this report was derived from EIA data, which is based on reported fuel sales. Note however that, unlike EIA and the SIT, this report does not include the natural gas used by pipeline equipment as part of the transportation sector fuel use. In this report, pipeline emissions are included in the Oil and Gas sector.

Figure 14 includes the CCAG estimate and projection for the transportation sector. The CCAG Report used a combination of data from EIA and the New Mexico Department of Transportation (NMDOT). However, updated data was not available from NMDOT and so could not be used in this report. For consistency, historical EIA data has been used in figures for transportation emissions.

Ethanol consumption has been deducted from the fuel sales reported by EIA in order to calculate GHG emissions from gasoline use. This is consistent with the calculation method used in the CCAG report and the SIT, and reflects an assumption that the CO_2 emitted during combustion of biomass-derived fuels is the same as the CO_2 drawn from the atmosphere during growth of the biomass, and as such results in no net increase in CO_2 emissions. Nonetheless, ethanol, like gasoline, can require significant upstream GHG emissions in production and refining.

4.3 Comparative Analysis

As discussed above, a comparison of CCAG estimates and projections is included in Figure 15. Despite differences in data sources, the trend reflected in the current update is consistent with the sector increase projected in the CCAG report.

Because transportation sector emissions are directly related to fuel use, personal and governmental efforts to reduce transportation fuel use serve to reduce, or at least slow the growth of, GHG emissions from the transportation sector. Such efforts include but are not limited to car and van pooling, increased use of public transportation, increases in average vehicle fuel efficiency, and traffic management to reduce vehicle idling times.

4.4 Significant issues

In 2007, the NM Environmental Improvement Board adopted Emissions Standards for New Motor Vehicles (20.2.88 NMAC), also referred to as the Clean Cars Rule. Section 177 of the CAA allows any State to adopt and enforce new motor vehicle standards that are identical to the California standards. The Clean Cars Rule applies to 2011 and subsequent model year vehicles and requires manufacturers to meet the fleet average non-methane organic gas (NMOG) exhaust emissions and GHG exhaust emissions standards set forth in the California Code of Regulations (CCR), Section 1961, for vehicles produced and delivered for sale in New Mexico. The rule also includes sales requirements for zero emission vehicles. The effects of this rule implementation may be evident in the next update to this report.

4.5 Key Uncertainties

Key uncertainties are included in the discussions of specific aspects of the transportation sector emissions. See also Section 5.5.

5 Emissions from Fossil Fuel Combustion in the Residential, Commercial, and (Non-Fossil Fuel Industry) Industrial Sectors

5.1 Emissions 2000-2007

This section reports the GHG emissions from fossil fuel combustion in the residential, commercial[31], and (non-fossil fuel industry) industrial sectors[32] (RCI). The residential and commercial sectors consume fossil fuels and electricity to heat and cool buildings and to power lights and appliances. The industrial sector consumes fossil fuels and electricity for these purposes and to heat and power industrial processes.

Fossil fuels include natural gas, oil (including gasoline and propane) and coal. While the combustion of fossil fuels results in emissions of N_2O and CH_4, more than 99% of the GHG emissions are in the form of CO_2.

Figure 16 and Figure 17 show the direct emissions from combustion of fossil fuels and the indirect emissions from electricity use in the residential and commercial sectors, respectively. Figure 18 shows the direct emissions from combustion of fossil fuels in the (non-fossil fuel industry) industrial sector. Figure 19 shows the indirect emissions from electricity use in the industrial sector, including the fossil fuel industry. From 2000 to 2007, the direct emissions resulting from combustion of fossil fuels in the residential, commercial and (non-fossil fuel industry) industrial sectors decreased by 3%, 5% and 2%, respectively.

As discussed in Section 1.5, between 2000 and 2007 the indirect emissions from the consumption of electricity in the residential and commercial sectors increased by 22% and 1%, respectively, and the indirect emissions from the consumption of electricity in the industrial sector (including the fossil fuel industry) increased by 19% (see Figure 19). Taking electricity consumption into account, the residential sector increased emissions from energy use by a total of 13% (taking into account the state's growing population, this is a per capita increase of 6%). During the same period, the total emissions from energy consumption in the commercial sector rose and fell, ending with 2007 emissions at 2000 levels.

[31] The commercial sector "consists of service-providing facilities and equipment of: businesses; Federal, State, and local governments; and other private and public organizations, such as religious, social, or fraternal groups. The commercial sector includes institutional living quarters. It also includes [energy consumed at] sewage treatment facilities" EIA 2002. *State Energy Data 2001, Technical Notes*, page 5. http://www.eia.doe.gov/emeu/states/sep_use/notes/use_intro.pdf.

[32] GHG emissions resulting from the fossil fuel industry are reported in Section 2. Industrial sector GHG emissions that result from processes (e.g., leakage, venting and non-combustion chemical processes) are reported in Section 6.

Figure 16 Residential Sector GHG Emissions from Combustion of Fossil Fuels

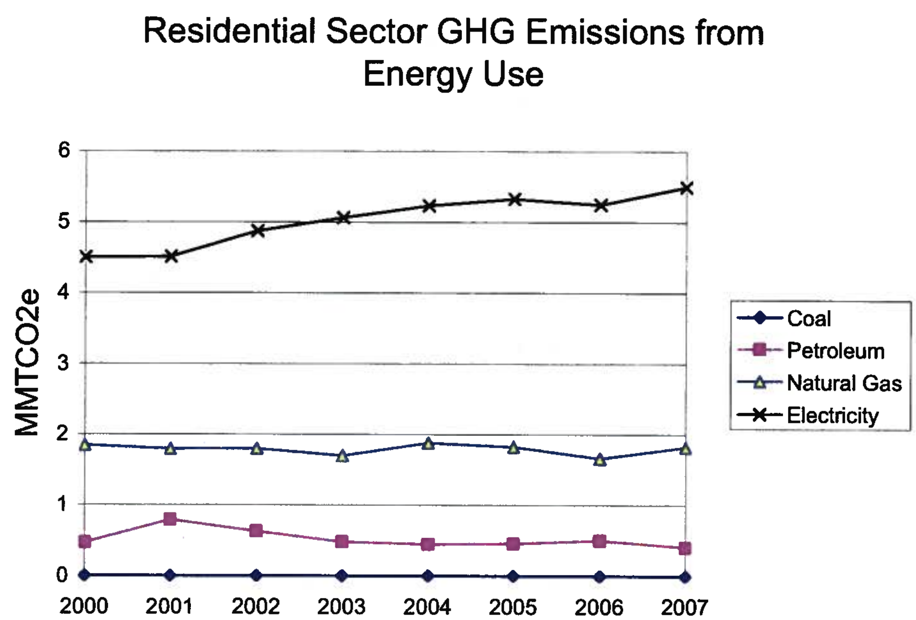


Figure 17 Commercial Sector GHG Emissions from Combustion of Fossil Fuels

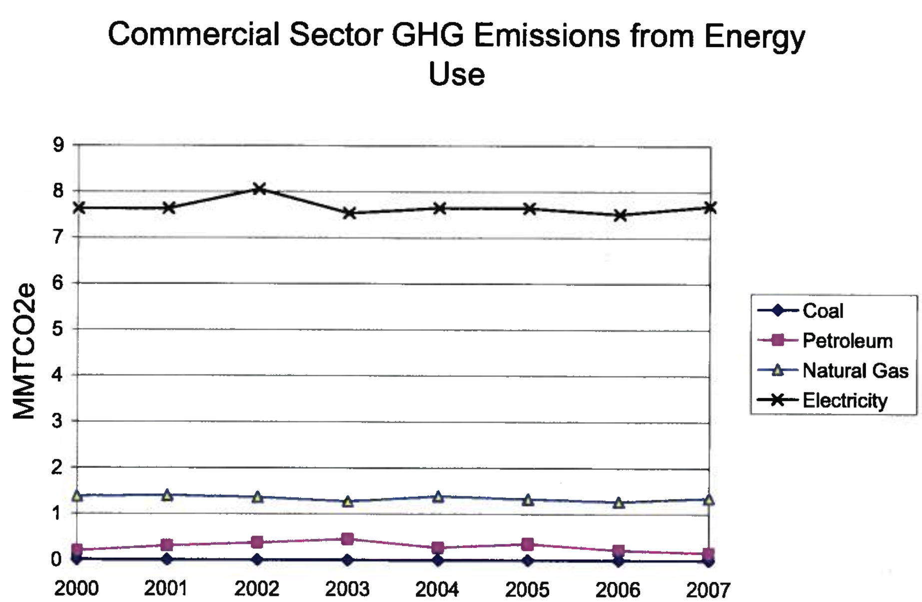


Figure 18 Industrial (Non-Fossil Fuel Industry) Sector GHG Emissions from Combustion of Fossil Fuels

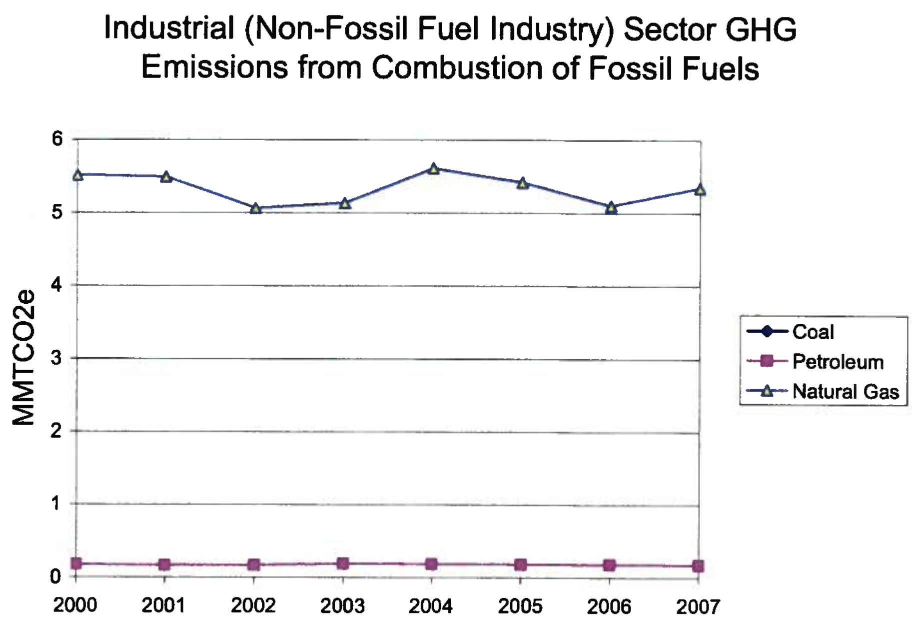
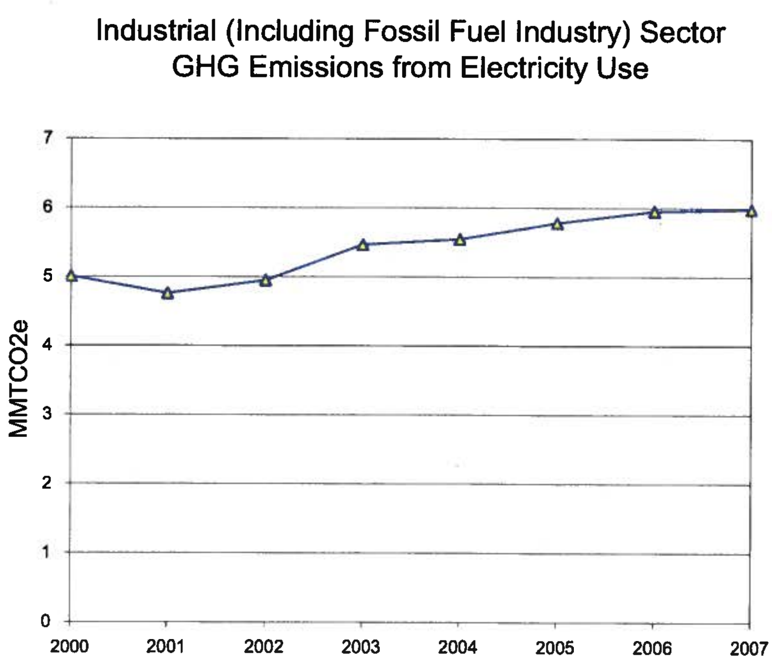


Figure 19 Industrial (Including Fossil Fuel Industry) Sector GHG Emissions from Electricity Use



5.2 Estimation Methodology & Data sources

The estimation methodology used in the CCAG Report and this report for emissions from fossil fuel combustion has been to multiply fuel use by an emissions factor for each fuel use and type of combustion device. Fuel use data is collected by the Energy Information Administration of the US Department of Energy and available to the public.[33] This information is also used as a data source for the SIT.

5.3 Comparative Analysis

In the figures for industrial emissions from energy use, the CCAG report includes the indirect emissions from electricity consumption. In this report, direct industrial sector emissions from the combustion of fossil fuels are reported in Figure 18, and the indirect emissions from consumption of electricity are included in Figure 19. In both reports, the estimated emissions from electricity use for the industrial sector includes the electricity consumed by the fossil fuel industry (not otherwise addressed in this section) as well as the non-fossil fuel related industries.

Emissions trends for these sectors are discussed above.

5.4 Significant issues

Significant issues are discussed above.

5.5 Key Uncertainties

The amount of CO_2 emitted from fossil fuel combustion depends on the type and amount of fuel consumed, the carbon content of the fuel, and the fraction of the fuel that is oxidized. Consequently, the more accurately these parameters are characterized, the more accurate the estimate of CO_2 emissions. Nevertheless, there are uncertainties associated with each of these parameters.

Although statistics of total fossil fuel and other energy consumption are relatively accurate at the national level, there is more uncertainty associated with the state-level data. In addition, the allocation of this consumption to individual end-use sectors (i.e., residential, commercial, industrial, and transportation) at the state level is more uncertain than at the national level.

Uses of fuels for non-energy purposes introduce additional uncertainty to estimating emissions, as the amount or rate at which carbon is emitted to the atmosphere can vary greatly depending on the fuel and use. This guidance and the SIT provide default values for the amount of non-energy use and percentage of carbon stored by fuel type, based on data collected at the national level. State-specific data can reduce these uncertainties.

In comparison with fuel consumption data, the uncertainties associated with carbon contents and oxidation efficiencies are relatively low. Carbon contents of each fuel type

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[33] www.eia.doe.gov. Specific NM information may be found at http://tonto.eia.doe.gov/state/state_energy_profiles.cfm?sid=NM#overview and http://www.eia.doe.gov/emeu/states/state.html?q_state_a=nm&q_state=NEW%20MEXICO.

are determined by the EIA by sampling and the assessment of market requirements, and, with the exception of coal, do not vary significantly from state to state. EIA takes into account the variability of carbon contents of coal by state in EIA's Electric Power Annual 2002 (2003b); these coefficients are also provided in the SIT.

6 Industrial Processes

6.1 Emissions 2000-2007

Emissions in this category span a range of activities, and indicate non-combustion sources of CO_2 from industrial manufacturing (cement, limestone and soda ash usage), the release of hydrofluorocarbons (HFCs) from cooling and refrigeration equipment, the use of various fluorinated gases in semiconductor manufacture (perflourocarbons or PFCs as well as HFCs), and the release of sulfur hexafluoride (SF_6) from electric power transmission and distribution.

6.2 Estimation Methodology & Data sources

Common sources of fugitive emissions of SF_6 are a result of leakage from gas-insulated substations and switchgear seals. It can also be emitted during equipment manufacture, installation, servicing and disposal. Emissions of SF_6 from electrical equipment have shown a slow decline from 2000-2007, believed to be a result of price increases during the 1990s and voluntary programs such as the EPA SF_6 Emission Reduction Partnership for Electric Power Systems[34]. The Industrial Process module of the SIT bases emissions on the quantity of SF_6 consumed annually, apportioned by state electricity sales divided by national electricity sales. This method assumes that all SF_6 consumed is used to replace SF_6 that was emitted. The module includes SF_6 consumption up to 2006. For 2007, US emissions of SF6 as CO_2e are apportioned by 2007 electricity sales divided by national electricity sales. This is the method recommended in the Emission Inventory Improvement Project (EIIP)[35]. The US emissions of SF_6 were listed in the Inventory of US Greenhouse Gas Emissions and Sinks: 1990 - 2007.

CO_2 is emitted from cement production during the calcination process, as calcium carbonate ($CaCO_3$) is converted to calcium oxide (CaO). Therefore, process emissions are directly related to the amount of clinker and masonry cement produced. The only cement plant in New Mexico, GCC - Rio Grande (a subsidiary of Grupo Cementos de Chihuahua), is located in Bernalillo County. Instead of using default production data, the CCAG report estimated Portland cement production from two sources (1997 Apparent use of Portland Cement by State and Market"[36] and the US Geological Survey's Cement Annual Report, 1997)[37]. The mean production was multiplied by the SIT emission factor, and then corrected based on production data from the New Mexico Greenhouse Gas Action Plan[38]. The application of this correction factor essentially attributes one-third of

[34] Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2007
http://www.epa.gov/climatechange/emissions/downloads09/InventoryUSGhG1990-2007.pdf

[35] Methods for Estimating Non-Energy Greenhouse Gas Emissions From Industrial Processes, August 2004. Prepared by: ICF Consulting. Prepared for: State and Local Climate Change Program, U.S. Environmental Protection Agency & Emission Inventory Improvement Program

[36] Not publically available.

[37] http://minerals.usgs.gov/minerals/pubs/commodity/cement/170497.pdf

[38] http://www.werc.net/outreach/Book.pdf

the combined AZ and NM production to the GCC - Rio Grande facility. For this report, a request for production data was made to the City of Albuquerque's Air Quality Division.

It must be noted that the draft Albuquerque City-wide and Bernalillo County Greenhouse Gas Emissions Inventory includes combustion related CO_2 emissions from GCC - Rio Grande, but does not include process emissions, generated through the calcination of lime, clinker production and masonry cement production. The fuel combustion emissions have been accounted for in the Residential/Commercial/Industrial section of this report.

Emissions from soda ash consumption were estimated from national usage, apportioned to NM by the State's population divided by the US population.

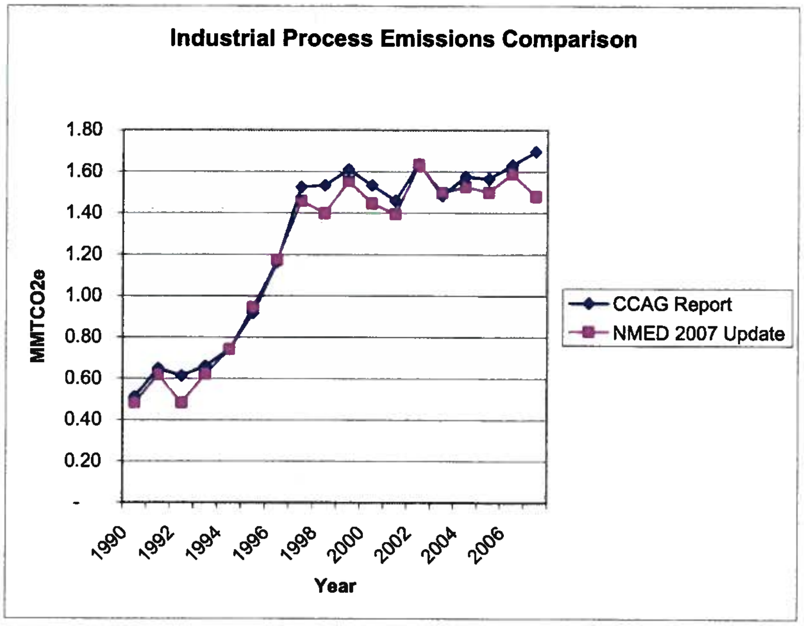
Emissions from lime manufacture, which also emits CO_2 during a chemical conversion, were not estimated for this update. The only lime plant in New Mexico is a chemical lime plant that imports lime manufactured elsewhere to produce hydrated lime. There are no CO_2 emissions generated from this process. Because the lime is actually produced outside of New Mexico, those CO_2 emissions are not attributed to New Mexico.

This update includes emissions from ammonia production and urea use. Although ammonia is not produced in New Mexico, urea is commonly used as the reagent in selective catalytic reduction (SCR) systems for the control of nitrogen oxides (NO_X).

6.3 Comparative Analysis

Figure 20 compares the data from the CCAG Report to the 2007 Update. For the period under review, the actual emissions are generally lower than those projected in the CCAG Report.

Figure 20 Industrial Process Emissions Comparison



The combined emissions related to industrial processes are shown in Figure 21 ($MMTCO_2e$). The trend has been a general increase in emissions from 2000 through 2007, with spikes in 2002 and 2006, mostly attributable to emissions from semiconductor manufacturing. However, the 2007 total emissions from industrial processes are only slightly higher than the 2000 emissions, 1.5 $MMTCO_2e$ vs. 1.4 $MMTCO_2e$, respectively. The contribution from the various sub-categories is shown in Figure 22.

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Figure 21 GHG Emissions from Industrial Processes 2000-2007

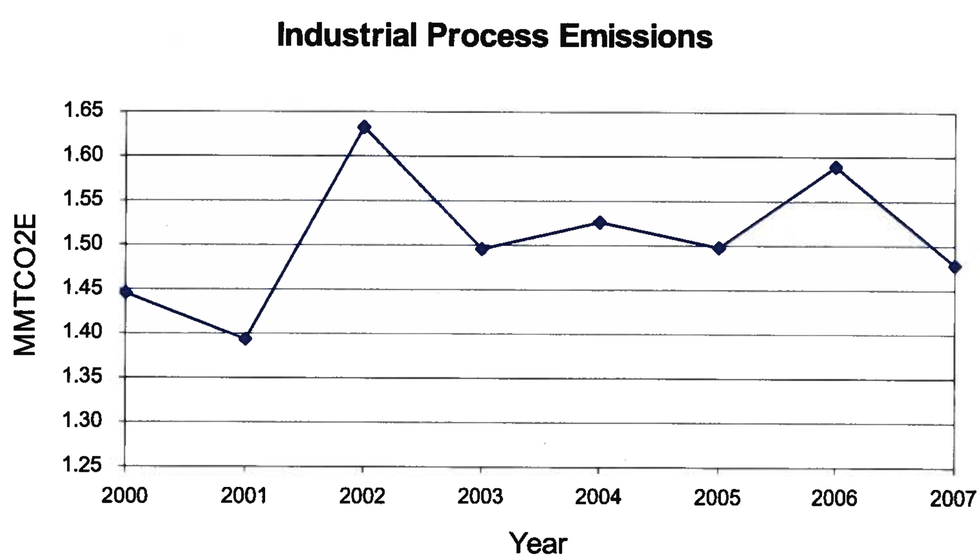
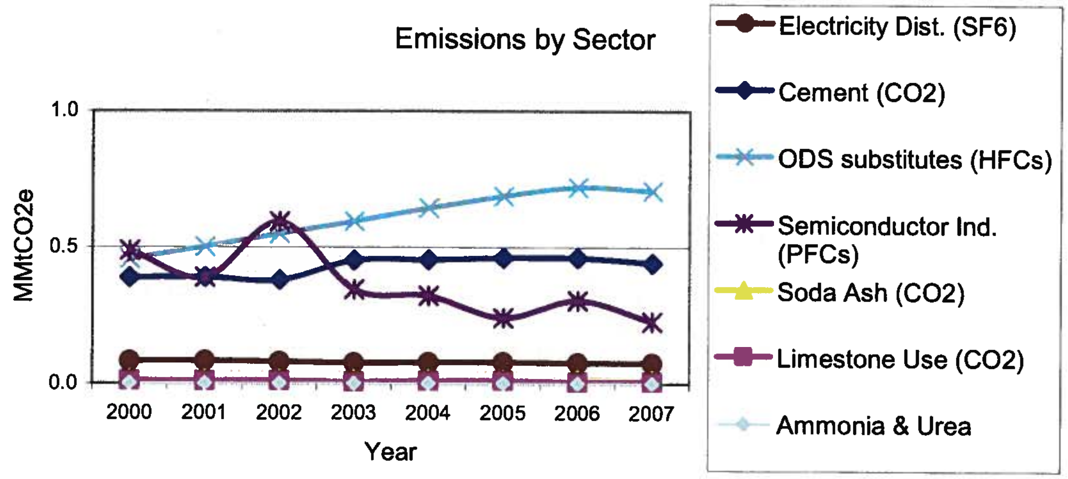


Figure 22 GHG Emissions from Industrial Processes by Sub-Category



In 2001, the use of ODS substitutes overtook the semi-conductor industry as the largest contributor of GHG emissions from industrial processes. Emissions from the use of ODS substitutes has gradually increased since 2000, leveling off in 2005, while semiconductor related emissions have significantly decreased, also leveling off in 2005. As with the previous inventory prepared by CCS, estimates of semiconductor emissions were obtained from Intel Corp.

HFCs continue to be used to substitute for ozone-depleting substances in compliance with the Montreal Protocol, which explains the steady growth in emissions of HFCs since 2000. Even low amounts of HFC emissions from leaks and normal use can lead to high GHG emissions. The emission estimates for New Mexico during the review period were based on EPA default data, apportioned based on state population. The Industrial Processes module included data up to 2006. To estimate the emissions for 2007, the same method was employed using the US emissions listed in the Inventory of US Greenhouse Gas Emissions and Sinks: 1990 - 2007.

6.4 Significant issues

See discussion above.

6.5 Key Uncertainties

Industrial process emissions continue to be determined by the level of production from a few key industries, and it remains difficult to obtain accurate production information, as such information may affect the competitiveness of New Mexico manufacturers and the specific nature of their production processes. For example, the USGS reports the combined production of the three cement plants in Arizona and New Mexico, and assumptions must be made to apportion production to the GCC - Rio Grande facility in

Bernalillo County. Emissions from other sectors are based on national production apportioned to New Mexico by the ratio of state population to national population.

7 Agriculture

7.1 Emissions 2000-2007

The agriculture sector of the GHG inventory constitutes 5 percent of the overall greenhouse gas emissions for New Mexico. The net emissions were 4 MMTCO2e in 2007.

Agricultural emissions include CH_4 and N_2O emissions from enteric fermentation, manure management, agricultural soils and agricultural residue burning.

CH_4 is produced as a waste product of digestion by ruminants such as cattle, in a process known as enteric fermentation. This CH_4 is released principally by belching. Cattle, buffalo, sheep, and goats account for the majority of methane emissions produced.

Manure management methods include the handling, storage and treatment of livestock waste. CH_4 is emitted when the manure is not stored in a sufficiently oxygenated environment, leading to anaerobic decomposition, while the nitrogen in livestock manure and urine encourages nitrification and de-nitrification, releasing nitrous oxide.

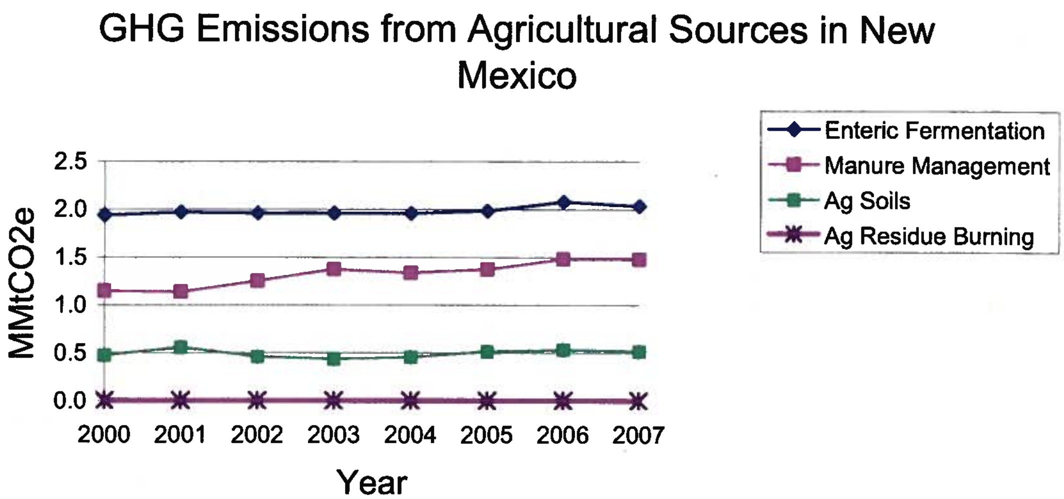
CH_4 and N_2O emissions from the storage and treatment of livestock manure (e.g., in compost piles or anaerobic treatment lagoons) occur as a result of manure decomposition.

Activities that increase the nitrogen in soil and thereby contribute to the category of N_2O emissions include fertilizer (synthetic, organic and livestock) application and production of nitrogen fixing crops.

Agricultural burning contributed a very small amount to the agricultural sector emissions.

Enteric fermentation is the greatest source of agricultural emissions, followed by manure management, agricultural soils and then agricultural residue burning (Figure 23).

Figure 23 GHG from Agricultural Sources in New Mexico



The Agriculture (Ag) module of the SIT was developed using Microsoft® Excel 2000. The SIT was developed in conjunction with EPA's Emissions Inventory Improvement Program.

7.2 Estimation Methodology & Data sources

The 2008 SIT was the primary methodology used for calculating GHG for the agricultural sector.

The sectors included within the Agricultural module are enteric fermentation, manure management, agricultural soils, and agricultural residue burning. Different methodologies exist for calculating the GHG emissions from each sector[39]. The module permits data entry or the selection of default data, which is entered into worksheets with prefabricated formulas. Data from the United States Department of Agriculture's National Agricultural Statistics Service (NASS) along with default data provided by the SIT were used in the SIT to calculate the GHG from the agricultural sector.

NASS conducts hundreds of surveys every year and prepares reports covering almost every aspect of United States agriculture. When available the NASS data were used in the SIT because they are specific to New Mexico and are reported annually. While these data may be coarser in scale, and not include age class, they are accurate and particular to New Mexico.

The default data available through the SIT provide a finer scale of data, including age class; these data are formulated based on national averages and are not factual reported data. Also the default data are only available through 2006 and the NASS data are available through 2008.

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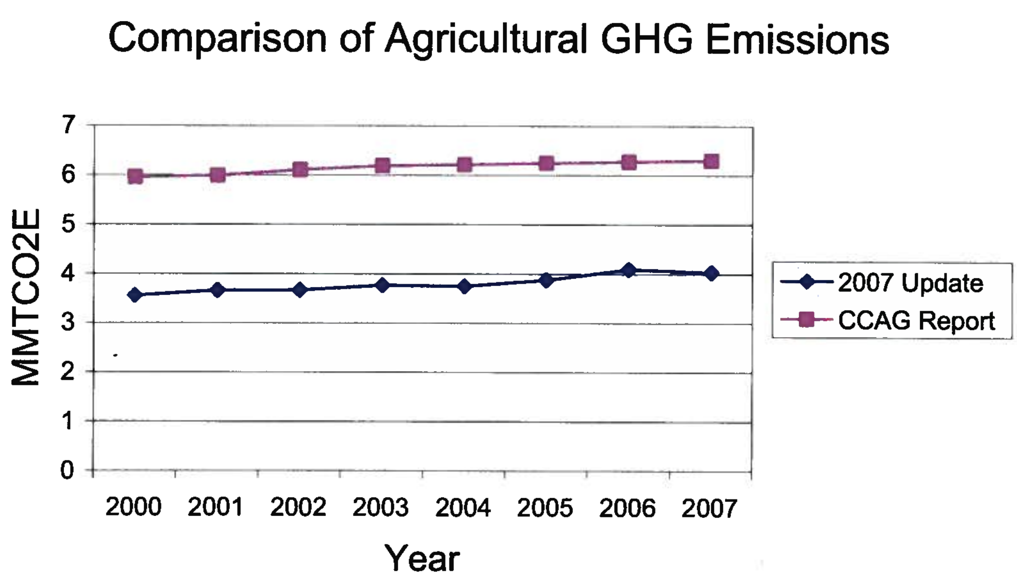
[39] ICF, International, 2008. Draft User's Guide for Estimating Methane and Nitrous Oxide Emissions from Agriculture Using the State Inventory Tool, July 2008.

7.3 Comparative Analysis

A comparison of the overall GHG emissions from CCAG Report to the 2007 Update shows that projections for 2004 through 2007 were slightly higher than the actual level of emissions. The projections showed a gradual increase in the level of emissions; however, the reported data shows more variation over this time horizon, including periods of swift increase and decrease in emissions levels.

The agricultural module of the SIT is regularly modified to include improved accounting methods. While both the CCAG Report and the 2007 Update calculations were completed using the SIT which had been modified and therefore the variation in the past and projected levels of emissions may be due to new methods implemented in the SIT.

Figure 24 Comparison of CCAG Report to 2007 Update: Agricultural GHG Emissions



In comparing the CCAG Report to the 2007 Update (see Figure 24) by agricultural source categories, the most significant change is that ag soils actually produced less tons of emissions than projected by the CCAG Report. The projections for the categories of enteric fermentation, manure management and ag residue burning were consistent with the CCAG Report. These sectors gradually increased over time at a very modest rate.

Nitrous oxide emissions are naturally produced in soils through the microbial processes of nitrification and de-nitrification. It is possible that the CCAG Report anticipated a higher demand for the use of nitrogen fertilizer for the production of high nitrogen consuming crops, like corn. There has been a significant and rapid increase in the construction activities of the nation's ethanol industry as many new plants throughout the

US Corn Belt opened[40]. However, New Mexico has not experienced the same rapid rate of growth in this industry. According to NASS, the production of "corn for grain" in New Mexico has ranged from 160 to 185 bushels from the year 2000 through 2009, but has not experienced rapid rates of growth or decline [41] (see Appendix A).

Another factor that may influence future emissions is New Mexico's Renewable Portfolio Standard's (RPS) program, which mandates greenhouse gas reduction goals through the requirement of the use of renewable energy sources in place of fossil fuel-based energy production.

The RPS recognizes biomass as an eligible source of renewable energy. In the agricultural sector, options for using renewable biomass resources, such as crops and residual material from agriculture, forestry or animal wastes, have been developed as low carbon energy sources for electricity production and/or bio fuels[42].

While biofuels may provide an alternative to fossil fuels, the complexity of this topic must be fully explored in order to deliver a sustainable biofuel industry. Not all biofuels perform at the same rate of efficiency in terms of their impact on climate, energy security and ecosystems. Factors such as population growth, yield improvements, changing diet patterns, climate change, availability of water, and land conversion for biofuels, as well as environmental and social impacts, must be assessed in order to achieve sound planning policies[43] .

7.4 Significant issues

New Mexico is nationally ranked seventh in total milk production and eighth in total cheese production (New Mexico Department of Agriculture 2007). However, the falling prices of milk have led to closure of several dairies in eastern New Mexico. Currently the dairies are receiving a net payment between $10 and $11 dollars per 100 pounds of milk, which is well below the accepted break even point of $16 per 100 pounds of milk. Ten dairies in Roosevelt and Curry counties have gone out of business since wholesale milk prices began dropping in 2008 (Duncan 2009). If the number of dairies continues to decline, then New Mexico may experience a decline in GHG from the agricultural sector.

7.5 Key Uncertainties

A detailed explanation of the key uncertainties according to the Agricultural module of the SIT is located in Appendix B.

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[40] Baker, Allen and Steven Zahniser 2006. Ethanol Reshapes the Corn Market. Amber Waves Volume 4, Issue 2, Economic Research Service/USDA.
http://www.ers.usda.gov/amberwaves/may07specialissue/features/ethanol.htm

[41] USDA National Agricultural Statistics Survey, Quick Stats, New Mexico Crops, 2009.
http://www.nass.usda.gov/

[42] State Action, Climate Change 101: Understanding and Responding to Global Climate Change, published by the Pew Center on Global Climate Change and the Pew Center on the States. January 2009.
www.pewclimate.org/docUploads/Climate101-State-Jan09.pdf.

[43] International Panel for Sustainable Resource Management, 2009. Towards Sustainable Production and Use of Resources; Assessing Biofuels. www.unep.fr.

8 Waste Management

8.1 Emissions 2000-2007

Greenhouse gas emissions from the waste management sector include solid waste management and waste water management. Municipal solid waste includes methane CH_4 emissions from landfilling of municipal solid waste and CO_2 and N_2O emissions from the combustion of municipal solid waste[44].

The following background information is provided by ICF International in the Draft User's Guide for Estimating Emissions from Municipal Solid Waste Using the SIT.

Greenhouse gases are emitted from landfills as CH_4 and CO_2 are produced from anaerobic decomposition of organic matter by methanogenic bacteria. Organic waste first decomposes aerobically (in the presence of oxygen) and is then decomposed by anaerobic non-methanogenic bacteria, which convert organic material to simpler forms like cellulose, amino acids, sugars, and fats[45].

Additionally, some landfills flare recovered landfill gas, which converts the CH_4 portion of the gas to CO_2. Also, there are some landfills that collect and burn landfill gas for electricity production or other energy uses (known as landfill-gas-to-energy projects, or LFGTE), which are treated similarly to landfills that flare their gas[46].

Table 5 identifies the following landfills to have flares or LFGTE systems.

Table 5 Landfills with Flares or GTE systems

Landfill	Flare or LFGTE system
Camino Real Landfill (Sunland park)	LFGTE and Flare
Rio Rancho Landfill (Rio Rancho)	Flare
Cerro Colorado (Albuquerque)	Flare
Los Angeles closed landfill (Albuquerque)	LFGTE

Neither the CO_2 emitted directly as biogas nor the CO_2 emitted from combusting CH_4 at flares is considered an anthropogenic GHG emission. The source of the CO_2 is primarily the decomposition of organic materials derived from biomass sources (e.g., crops, forests), and in the United States these sources are grown and harvested on a sustainable basis. Sustainable harvesting implies that photosynthesis, which removes CO_2 from the atmosphere, is equal to decomposition, which adds CO_2 to the atmosphere. However, some CO_2 is from non-biogenic sources (e.g., plastic and rubber made from petroleum), and is counted in GHG emission inventories.

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[44] ICF, International, 2008. Draft User's Guide for Estimating Methane and Nitrous Oxide Emissions from Agriculture Using the State Inventory Tool, July 2008

[45] Ibid.

[46] Ibid.

N_2O is produced at the high temperature found in waste combustors by the combination of nitrogen (contained in both the waste and in the air) and oxygen gas in the air[47].

Waste-related greenhouse gas sinks and carbon storage from landfilled yard trimmings and food scraps are not accounted for in solid waste management[48] .

8.2 Wastewater Emissions

Wastewater management includes methane and nitrous oxide from municipal wastewater treatment facilities. Wastewater emissions were calculated using the SIT. The calculated values are approximately 70% of the values calculated in 2004. The calculation methodology for municipal wastewater N_2O emissions has changed as emissions from this category are approximately 50% less than the values calculated in 2004. The net effect of this change is that total emissions from this category are 30% less than the values calculated in 2004. Therefore 2007 emissions from this sector are 0.19 ($MMTCO_2E$) instead of 0.27 ($MMTCO_2E$) as projected in 2004. However, the annual rate of change has consistently been approximately 2.1%. Wastewater emissions are largely a function of population growth and the estimated 1.0% annual estimated population growth has been realized between 2003 and 2007 as projected.

EPA reports the changes noted above reflect that the default factor for N_2O emissions from nitrogen in effluent discharged changed from 0.01 to 0.005 kg N_2O-N/kg sewage N-produced, to be consistent with the US National Inventory. Furthermore, the fraction of the population not on septic was updated from 75% to 79%, also to be consistent with the factors used in the US National Inventory. The combination of these two changes resulted in the net change of emissions in 2007 when compared to 2004.

8.3 Estimation Methodology & Data Sources

The 2008 SIT was used to determine the GHG emissions for this sector. The emissions from these types of facilities are site specific and the NMED Solid Waste and Air Quality bureaus provided more specific data than the default data provided by the SIT.

The data provided by the Solid Waste Bureau in their Annual Reports include the tonnages of waste landfilled and diverted, including tonnages of waste from out-of-state sent to NM for disposal. This information is not compatible with the SIT and is provided in Appendix D.

8.4 Comparative Analysis

The 2007 Update shows that emissions are slightly lower than projected in the CCAG Report (see Figure 25). The emissions steadily increase over time without abrupt increases or declines.

The emissions from the waste sector are related to the growth rate in New Mexico. With increased population, emissions from solid waste will increase. The growth rates are projected to increase at 1.2% and the emissions reflect this growth rate.

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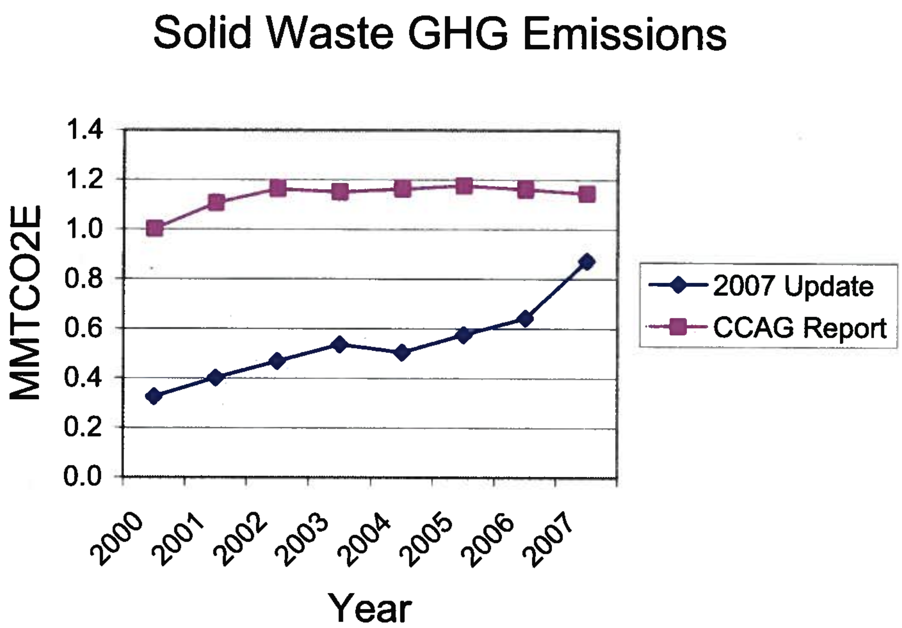
[47] Ibid.

[48] Ibid.

Figure 25 Comparison of Solid Waste GHG Emissions CCAG Report to 2007 Update



8.5 Significant issues

The growth rate in New Mexico plays an important role in waste emissions. The state population grew 6.7% from 2000-2007 at approximately 1% per year[49]. Analysis done by the Bureau of Business & Economic Research at the University of New Mexico indicates that this growth rate is low in light of other economic and demographic indicators for the state[50].

8.6 Key Uncertainties

According to the SIT, the following uncertainties exist. Uncertainty surrounds key elements of these calculations, including the activity data and factors.

1. Uncertainty of Estimating Methane Emissions from Municipal Landfills

There are several sources of uncertainty associated with the recommended method for estimating CH_4 emissions from landfills. CH_4 production is impacted by temperature, rainfall, and landfill design, characteristics that vary by each landfill and cannot be accounted for individually. Additionally, the time period over which landfilled waste produces CH_4 also is not certain. This methodology is based on information from CH_4 recovered from various landfills, which may not be representative of landfills as a whole. Little information is available on the amount of CH_4 oxidized during diffusion through the soil cover over landfills. The assumed ten percent is based on limited measurements.

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[49] From the US Census Bureau's annual population estimates from 4/1/00 to 7/1/07 (NST-EST2007), released 12/27/07

[50] Bureau of Business & Economic Research at the University of New Mexico, Statistics at a Glance, 2009. http://bber.unm.edu/

In addition, the methodology presented here assumed the waste composition of all landfills is the same; in reality, waste in different landfills likely varies in composition. The presence of landfill gas recovery systems may affect activity in the anaerobic zones of landfills, since active pumping may draw more air into the fill, thus inhibiting methanogenesis.

2. Uncertainty of Estimating Greenhouse Gas Emissions from Municipal Solid Waste Combustion

There are several sources of uncertainty surrounding the estimates of CO_2 and N_2O from waste combustion, including combustion and oxidation rates, average carbon contents, and biogenic content. Due to variation in the quantity and composition of waste, the combustion rate is not exact. Similarly, the oxidation rate is uncertain because the efficiency of individual combustors varies depending on type of waste combusted, moisture content, and other factors. Average carbon contents are used for "other" plastics, synthetic rubber, and synthetic fibers. However, the actual carbon content of these materials may vary depending on the specific composition of each material. Non-biogenic CO_2 emissions from waste combustion depend on the amount of non-biogenic carbon in the waste, and the percentage of non-biogenic carbon that is oxidized. EPA used simplifying assumptions that (1) all carbon in textiles is non-biomass carbon (i.e., petrochemical-based plastic fibers such as polyester), and (2) the category of rubber and leather is composed almost entirely of rubber. The resulting estimate of CO_2 emissions from waste combustion slightly overstates the emissions.

9 2008 Title V GHG Emissions Reporting

The inaugural GHG reporting year, 2008, required GHG emission reports for carbon dioxide emissions only from Title V sources exclusive of those located on tribal lands and within Bernalillo County. New Mexico has about 150 Title V sources and most of these sources emit carbon dioxide primarily from combustion (see Table 6). NMED created its original GHG reporting rules to require emissions from these sources (i.e., the state's largest facilities). There were a few Title V sources that did not report GHG emissions as they either did not have any CO_2 emissions or did not operate during emissions year 2008. NMED received CO_2 emissions reports from all but eleven of the Title V sources that operated.

New Mexico's 2008 GHG reporting procedures for CO_2 mirrored California Air Resources Board (CARB) GHG reporting rule but also allowed facility operators to voluntarily report emissions to The Climate Registry[51]. The large electric utilities generally used Continuous Emissions Monitoring (CEMS) data to report CO_2 emissions. Owners of combustion sources generally recorded fuel consumption and used emission calculation methods containing default carbon or heat content data to facilitate emissions reporting. Sources not able to use these default data had to analyze fuel to determine its heat and carbon content(s). All facilities recorded and reported fuel consumption. Additional reporting details were required from power plants and petroleum refiners subject to 20.2.87 NMAC.

Total GHG emissions from Title V reporting sources were approximately 24.2 $MMTCO_2$ (See Table 6). The electric services industry consisted of 65% of the total GHG emissions with Public Service Company of New Mexico's coal fired San Juan Generating Station contributing approximately 10.8 $MMTCO_2$. The oil and gas sector contributed approximately 33% of the total emissions with TEPPCO NGL Pipelines LLC contributing the largest share from this sector at 1.34 $MMTCO_2$ (see Figure 26). The top 25 GHG-emitting sources listed in Table 6) contributed approximately 90% or 21.6 $MMTCO_2$ of reported GHG emissions. It's expected that the contribution of GHG emissions from the oil and gas sector will increase slightly in 2009 when GHG emissions inventory reports include methane emissions.

NMED's emissions data collection system used to report 2008 emissions data was cumbersome which increased the potential for data reporting and analysis errors. NMED is in the process of enhancing its data collection system to facilitate reporting and analysis of GHG and criteria pollutant emissions data. The use of natural gas default data did not work well for combustion sources of coal bed methane (CBM) gas as its heating value is lower than conventional gas. CBM gas combustion default data would ease reporting burden for sources combusting CBM gas. The CO_2 vented emissions data from gas processing plants and gas compressors are somewhat limited as our procedures focused on combustion related, not vented, sources of emissions.

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[51] http://www.theclimateregistry.org.

The quality and breadth of GHG emissions data may be increased by implementation of the following:

- EPA's mandatory GHG reporting rule;
- Changes to New Mexico's GHG reporting rules;
- Improvements in NMED's emissions data reporting tools; and
- Development of robust oil and gas emissions reporting emissions calculation methods.

Figure 26 2008 CO2 Emissions Reported by NM Title V Sources

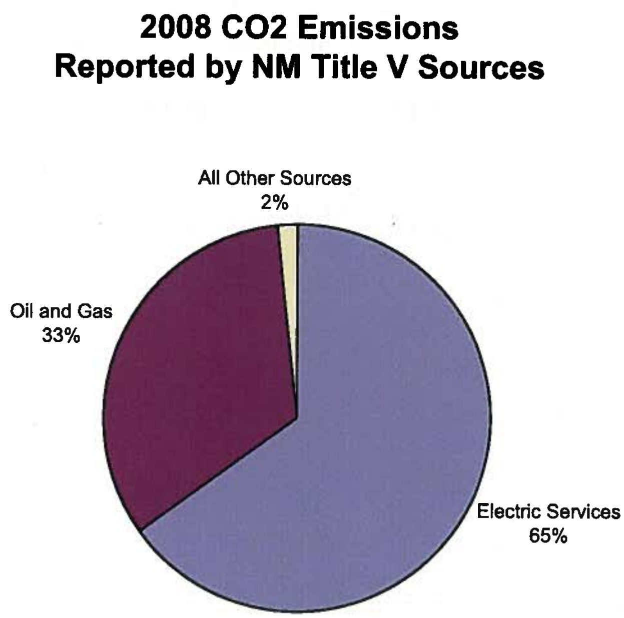

Table 6 2008 Title V GHG Emitting Sources 10,000 metric tons and greater (Thousand Metric Tons).

Facility Name	***AI_ID***	***SIC***	***Emissions***
Public Service Co of NM - San Juan Generating Stn.	1421	4911	10797.5
Prewitt Escalante Generating Station	911	4911	1755.1
Milagro Cogeneration and Gas Plant	1277	1389	1500.5
Val Verde Treater	1182	1321	1340.2
Luna Energy Facility	878	4911	905.8
Xcel Energy - Cunningham Station	604	4911	881.4
Navajo Refining - Artesia Refinery	198	2911	624.2
El Paso Electric - Rio Grande Generating Station	122	4911	461.7
Chaco Gas Plant	1148	1311	395.3
Afton Generating Station	164	4911	329.2
Maddox Station	588	4911	310.0
Ciniza Refinery	888	2911	264.5
Blanco Compressor C and D Station	3552	1311	263.5
San Juan Gas Plant	1177	1321	244.1
Jal No3 Gas Plant	569	1321	226.8
Targa - Eunice Gas Plant	609	1321	187.8
Linam Ranch Gas Plant	589	1321	164.2
Duke Energy Field Services - Eunice Gas Plant	595	1321	146.1
Kutz Gas Plant	1158	1321	141.2
Bluffview Power Plant	3535	4911	135.7
Indian Basin Gas Plant	197	1321	111.3
Intrepid Potash - East KCl Compaction	208	1474	106.6
Bloomfield Refinery	1156	2911	103.5
El Cedro Gas Plant	1002	1311	100.5
Monument Gas Plant	610	1321	96.4
Lovington Refinery	622	2911	93.8
Chino Mine - Hurley Facility	526	1021	87.8
La Jara Compressor Station	1010	1389	82.2
Pecos River Compressor Station	194	4922	81.1
Saunders Gas Plant	612	1321	67.0
Artesia Gas Plant	199	1321	66.1
East Vacuum Liquid Recovery	638	1311	65.4
Denton Gas Plant	568	1321	64.3
Animas Plant	1159	4911	63.1
San Juan River Gas Plant	1252	1321	62.1
Lordsburg Compressor Station	553	4922	61.3
Lybrook Gas Plant	979	4922	58.6
DairiConcepts - Portales	1094	2023	50.7
Rattlesnake Canyon Compressor Station	1423	4922	47.0
Florida Compressor Station	868	4922	45.8
Gobernador/Manzanares Compressor Station	989	4922	44.9
Mosaic Potash Carlsbad Inc	196	1474	43.6
Dogie Canyon Compressor Station	990	4922	42.5
North Eunice Compressor Station	602	1311	42.5

Facility Name	***AI_ID***	***SIC***	***Emissions***
Pump Canyon Compressor Station	1183	4922	41.7
Eunice A Compressor Station	566	4922	41.5
32-8 No2 CDP Compressor Station	1236	1389	40.9
Empire Abo Gas Plant	191	1321	40.6
32-7 CDP Compressor Station	1221	1389	40.3
Monument Compressor Station	571	1311	38.6
Trunk L Compressor Station	1037	1389	37.2
Wingate Fractionation Plant	884	1321	36.8
Afton Compressor Station	123	4922	35.0
South Carlsbad Compressor Station	218	4922	32.9
American Gypsum - Bernalillo (Wallboard) Plant	1104	3275	32.1
Los Alamos National Laboratory	856	9711	31.2
Frances Mesa Compressor Station	1038	1389	30.5
Lordsburg Generating Station	560	4911	29.9
Laguna Seca Compressor Station	1011	1389	29.8
Middle Mesa CDP Compressor Station	1272	1389	27.8
New Mexico State University Campus	144	8221	26.8
Chaco Compressor Station	1189	1389	26.3
Cedar Hill Compressor Station	1331	4922	25.7
Blanco Compressor Station A	1147	4922	24.4
Espinosa Canyon Amine Plant	21709	1311	24.2
Huerfano Pump Station	1201	4619	23.9
Williams Four Corners - 30-5 CDP Compressor Stn.	998	1389	23.8
San Ysidro Pump Station	1114	4619	23.4
Bloomfield Compressor Station	1192	4922	22.8
Trunk N Compressor Station	1303	1389	22.4
Frontier Field Services - Maljamar Gas Plant	565	1321	22.1
Pyramid Generating Station	558	4911	22.1
29-6 CDP No2 Compressor Station	1007	1389	21.3
Golfcourse Booster Station	592	1311	21.1
Monument Booster Station	593	1311	20.6
Thompson Compressor Station	1191	1389	19.8
Pump Mesa Compressor Station	1273	1389	19.4
Targa - Vada Compressor Station	613	1311	18.0
West Eunice Compressor Station	755	1311	17.3
32-8 No3 CDP Compressor Station	1168	1389	17.0
Antelope Ridge Gas Plant	621	1321	16.4
South Hat Mesa Booster Station	665	4922	16.1
San Luis Pump Station	1109	4619	16.0
Trunk B Compressor Station	1350	1389	15.4
Rosa No1 Compressor Station	1367	1389	15.0
Eunice B&C Compressor Station	669	4922	14.7
Horse Canyon Central Delivery Point	1274	1389	14.5
Trunk A Booster Compressor Station	1342	1389	14.5
Quail Booster Station	679	1311	14.3
Buena Vista Compressor Station	1315	4922	13.4
29-6 No4 CDP Compressor Station	1013	1389	13.2
Oil Center Compressor Station	668	4922	13.2
32-9 Central Delivery Point (CDP)	1226	1389	12.5

Facility Name	*AI_ID*	*SIC*	*Emissions*
Bitter Lake Compressor Station	14	4922	11.9
Belen Compressor Station	1590	4922	11.2
Carracas CDP Compressor Station	1009	1389	11.2
Lateral N30 Compressor Station	1347	1389	11.2
Hart Canyon Compressor Station	1181	4922	11.2
MCA Tank Battery No2	624	1311	11.1
Middle Mesa Compressor Station	1193	4922	10.9
Total from sources >10K metric tons			**24040.5**
2008 TV Inventory Total			**24206.6**
Percent of TV mandatory reporting GHG Inventory			**99.3**

Note: Does not include CH4 emissions and underestimates CO2 emissions from sour gas plants.

10 WRAP / WCI Oil and Gas Protocol Development Project

NMED in conjunction with CARB, TCR and WRAP participated in the WRAP oil and gas protocol development project. This project provided a review of the sources and types of GHG emissions from the upstream oil and gas sector, and the following three work products:

1. An oil and gas scoping paper that discusses this sector in the west with a primary focus on four WCI states (including New Mexico) having significant oil and gas sector activities;
2. An analysis on a basin level of significant sources of GHG emissions and an evaluation of emissions calculation methods used to estimate GHG emission from these significant sources; and
3. A voluntary emissions reporting protocol subject to TCR Board approval in January 2010 to facilitate voluntary reporting.

The WRAP process included a Technical Work Group (TWG) consisting of government, industrial and non-governmental entities. Periodic phone conferences and three in-person meetings were held to discuss significant technical and policy issues and review draft documents regarding oil and gas GHG emissions reporting. Although the WRAP oil and gas protocol development process did not result in a mandatory reporting protocol, the work product(s) will inform the WCI mandatory reporting committee's oil and gas model rule development (see http://wrapair.org). Specific areas of interest to the WCI reporting committee include policy issues related to aggregation and contractor emissions, technical issues related to emission calculation, and direct measurement methods for estimating fugitive methane emissions.

WCI's reporting committee expects to develop essential requirements for mandatory reporting of greenhouse gas emissions for oil and gas production and gas processing. This work is now underway and is expected to be completed in 2010. The EPA is expected to promulgate reporting rules for these sectors as amendments to its Mandatory Reporting Rule in 2010, and the WCI reporting committee will then address harmonization of the WCI requirements with the EPA rule. WCI will attempt to minimize harmonization issues by involvement of EPA in the WCI process.

Appendix A: Corn for Grain Produced in New Mexico

Corn for Grain produced in New Mexico 2000 – 2007
Source: NASS

	2000	2001	20002	2003	2004	2005	2006	2007
Bushels	160	180	175	180	180	175	185	180

Appendix B: Key Uncertainties in Agricultural Module of SIT

According to the SIT, the following uncertainties exist.

1. Domesticated Animals

The quantity of methane (CH_4) emitted from enteric fermentation from livestock is dependent on the estimates of animal populations and the emission factors used for each animal type. Therefore, the uncertainty associated with the emission estimates stems from those two variables. Animal populations fluctuate throughout the year, and thus using a single point estimate (e.g., horses and sheep), multiple point estimates (e.g., cattle and swine), or periodic estimates (e.g., goats) introduces uncertainty into the average annual estimates of these populations. In addition, there is uncertainty associated with the original population survey methods employed by USDA.

Emission factors vary in each animal, depending on its production and diet characteristics, as well as genetics. This makes determining an exact emission factor for each state and all possible animal sub-groupings impossible. However, for cattle, these variables were simulated when estimating emissions for the United States (EPA 2004), thus providing a reasonable average for the regions defined in this analysis. While some of the characteristics used for cattle differ from the IPCC default values, a review of the US situation determined that these factors are justified. For other (non-cattle) animal populations there is also uncertainty associated with the emission factors, but it is believed not to vary as drastically within each species.

2. Livestock Manure

Similar to emission estimates of methane from enteric fermentation, emissions from manure management are dependent on the estimates of animal populations and the various factors used for each animal type. Therefore, the uncertainty associated with the emission estimates stems from those variables. Animal populations fluctuate throughout the year, and thus using a single point estimate (e.g., horses and sheep), multiple point estimates (e.g., cattle and swine), or periodic estimates (e.g., goats) introduces uncertainty into the average annual estimates of these populations. In addition, there is uncertainty associated with the original population survey methods employed by USDA.

The largest contributors to uncertainty in emissions from manure management are the lack of extensive data describing the management systems used in each region, and the methane generating characteristics used to estimate emissions from each of these systems. Also, the nitrous oxide emission factors are derived from a limited data set and are provided as global estimates, not country or state specific.

In particular, methane conversion factors (MCFs) vary widely for anaerobic lagoon systems, based on design and handling procedures. The default range from the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC 2000) is between zero and 100 percent, reflecting the vast discrepancies that can occur in this type of system. In the United States, MCFs were estimated based on observed system performance and climatic factors, though the methodology employed introduces additional uncertainty because it is based on data from relatively few systems (EPA 2004).

In addition, there is uncertainty in the maximum methane producing potential (Bo) used for each animal group. This value varies with both animal and diet characteristics, so estimating an average across an entire population introduces uncertainty. While the Bo values used in this analysis vary by animal subcategory to try to reflect as many of these differences as possible, there is not sufficient data available at this time to estimate precise values that accurately portray the Bo for all animal types and feeding situations (EPA 2004).

Finally, nitrous oxide emission factors used for this analysis are the global defaults provided by the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC 2000). These factors are based on limited studies, and do not take into account the fact that US emission factors may vary significantly on both a national and state level.

3. Agricultural Soil Management

The amount of nitrous oxide (N_2O) emissions from managed soils is dependent on a large number of variables besides nitrogen (N) inputs, including soil moisture content, pH, soil temperature, organic carbon availability, oxygen (O_2) partial pressure, and soil amendment management practices. However, the effect of the combined interaction of these variables on N_2O flux is complex and highly uncertain. The IPCC default methodology that is followed here is based only on N inputs and does not incorporate other variables. As noted in the Revised 1996 IPCC Guidelines (IPCC/UNEP/OECD/IEA 1997), this is a generalized approach that treats all soils equally, with the exception of cultivated histosols (EPA 2004). This methodology covers the following three sub-categories: direct emissions due to cropping practices, direct emissions due to animal production, and indirect emissions from agricultural applications of N. Uncertainties exist in both the emission factors and activity data used to derive emission estimates in each sub-category.

As noted in Section 2.2, scientific knowledge is limited regarding N_2O production and emissions from soils to which nitrogen is added. Thus it is not currently possible to develop statistically valid estimates of emission factors for all possible combinations of soil, climate, and management conditions. The emission factors presented throughout this chapter are midpoint estimates based on measurements described in the scientific literature. They are representative of current scientific understanding, but also possess a significant level of uncertainty.

Uncertainties also exist in the default activity data used to derive emission estimates in each sub-category. In particular, the fertilizer statistics do not include non-commercial fertilizers (except estimated manure and crop residues). Site-specific conditions are not taken into consideration when determining the amount of nitrogen excreted from animals. Limited research on nitrogen-fixing crops has resulted in the use of conversion factors that may not account for the variety of conditions in all states. Expert judgment, with its inherent uncertainty, was used to estimate the amount of crop residues left on soils as no data were available.

Additional uncertainty surrounds the emission sub-categories for which state-level data may not be available, i.e., land application of sewage sludge and cultivation of histosols. Emissions of N_2O due to leaching and runoff are also relatively uncertain at this time, due to the uncertainty of the volatilization rates and proportion of leached nitrogen.

4. Agricultural Crop Wastes

The methodologies presented in this chapter account for non-carbon dioxide emissions, including methane, nitrous oxide, carbon monoxide, and nitrogen oxides, from field burning of agricultural residues. As in the Inventory of US GHG and Sinks, major sources of uncertainty in this sector are the quantity of residue burned per year and the variability in states' burning practices (US EPA 2004). Both the emission factors and activity data introduce uncertain elements into the calculations.

The gas emission ratios have a relatively high level of uncertainty as they are region-specific (not country- or state-specific). Low level uncertainty also surrounds residue dry matter content, burning efficiency, and combustion efficiency values used (US EPA 2004).

Since there is no national or state-level collection of data on the fraction of crop residue burned, and burning practices vary by state and crop, these data are highly uncertain. Additional sources of uncertainty include crop production data and residue to crop production ratios at low levels (US. EPA 2004).

Appendix C: Database of State Incentives for Renewables & Efficiency 2008

The following information provided by the Database of State Incentives for Renewables & Efficiency 2008 gives an overview of the RPS program.

Background

In December 2002, the Public Regulatory Commission PRC unanimously approved a renewables portfolio standard (RPS) requiring investor-owned utilities to derive 5% of annual retail sales to New Mexico customers from renewable energy sources by 2006, rising to 10% by 2011. In March of 2004, Senate Bill 43 codified the PRC rules and established additional requirements. New Mexico subsequently doubled its RPS for investor-owned utilities and created a separate standard for rural electric cooperatives in March 2007 (Senate Bill 418).

Summary

In March 2007, New Mexico passed SB 418, which directs investor-owned utilities to generate 20% of total retail sales to New Mexico customers from renewable energy resources by 2020, with interim standards of 10% by 2011 and 15% by 2015. The bill also establishes a standard for rural electric cooperatives of 10% by 2020. Furthermore, utilities are to set a goal of at least 5% reduction in total retail sales to New Mexico customers, adjusted for load growth, by January 1, 2020.

Renewable energy is defined as electric energy generated by low- or zero-emissions generation technology with substantial long-term production potential; solar; wind; geothermal; hydropower facilities brought in service after July 1, 2007; fuel cells that are not fossil fueled; and biomass resources, such as agriculture or animal waste, small diameter timber, salt cedar and other phreatophyte or woody vegetation removed from river basins or watersheds in New Mexico, landfill gas and anaerobically digested waste biomass. Renewable energy does not include electric energy generated from fossil fuel or nuclear facilities.

Utilities document compliance with the RPS through the use of renewable-energy certificates (RECs). A REC represents one kilowatt-hour (kWh) of renewable electricity. RECs used for RPS compliance on or after January 1, 2008 must be registered with the Western Renewable Energy Generation Information System (WREGIS). RECs not used for compliance, sold, or otherwise transferred may be carried forward for up to four years (Database of State Incentives for Renewables & Efficiency 2008).

Appendix D: Annual Solid Waste Reports

Source and Management	2004	2005	2006	2007	2008
Generated in New Mexico	3,004,965	3,077,680	3,279,954	3,226,933	2,962,096
Waste from Out-of-State	564,018	471345	626,598	665,627	613,025
Waste Diverted from Landfills	157,986	114169	406,745	433,186	383,627
Total Solid Waste Disposed in New Mexico Landfills	3,410,997	3,434,856	3,499,807	3,459,374	3,191,494

These numbers are slightly different than the tonnages published in the Annual Report because the data continues to be entered as the facilities annual tonnages are reported.